PARASITOLOGY

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PARASITOLOGY

EDITED BY

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PARASITOLOGY

EDITED BY

GEORGE H. F. NUTTALL, M.D., PH.D., SC.D., LL.D., F.R.S.

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THE NEMATODE PARASITES OF VERTEBRATES

By WARRINGTON YORKE, M.D.,
Professor of Parasitology, University of Liverpool
and Liverpool School of Tropical Medicine, and
P. A. MAPLESTONE, M.D., D.S.O.

Foreword by C. W. STILES,
Professor of Zoology, United States Public Health Service

CONTENTS: Introduction — Superfamily RHABDIASOIDEA — Superfamily TRICHUROIDEA — Superfamily STRONGYLOIDEA — Superfamily DIOCTOPHYMOIDEA — Superfamily OXYUROIDEA — Superfamily ASCAROIDEA — Superfamily SPIRUROIDEA — Superfamily FILARIOIDEA — Genera insufficiently known and of uncertain Systematic Position — Collective Group Names for Immature Nematodes — Glossary and Explanatory Notes — Index of Generic Names and Synonyms — Index of Specific Names — References.

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VOLUME XVIII JANUARY, 1926 No. 1

THE MALLOPHAGAN FAMILY MENOPONIDAE.

BY G. F. FERRIS.

Stanford University, California.

PART II[1].

(With 1 Text-figure.)

CONTENTS.

B. The types of the existing genera (*cont.*).
6. *Eomenopon denticulatus* Harrison.

6. **Eomenopon denticulatus** Harrison.

Material examined. A male and a female from *Trichoglossus novae-hollandiae* in a bird store in San Francisco. This is one of the type host species and the specimens agree entirely with Harrison's description, making the determination quite positive.

Female (Fig. 6 *A*). A rather robust form with strong chitinization. *Head* short, about twice as wide as long, widest close to the posterior border, anterior margin somewhat parabolic. Lateral margins very slightly concave, with a very deep slit just anterior to the region of the eye, slightly swollen in front of this slit (Fig. 6 *F*). Antennary fossa (Fig. 6 *G*) very deep, with a very small ventral floor, backed up by a region of very heavy chitinization which extends forward past the antennal base to the anterior margin of the head where it terminates in a strong, backward-pointing, external spine. Antennae (Fig. 6 *B*) apparently but three-segmented. Palpi slender. Gular region with a faintly chitinized plate which bears a marginal series of long setae. Pharyngeal sclerite and glands apparently entirely lacking.

Prothorax large and broad, with narrow wings, the lateral margins quite strongly convergent but forming a rounded angle with the posterior margin; sternum consisting of a small, but distinct, plate which bears no setae. *Mesothorax* short, but quite distinct, the notum consisting chiefly of a distinctly chitinized transverse bar which extends to the ventral side and articulates with the band forming the acetabular margin of the middle legs; sternum consisting of an extremely small piece which bears three or four small setae. *Metathorax* somewhat shorter than the prothorax, its lateral margins strongly divergent, its posterior margin straight; sternum consisting of a rather large plate which bears numerous small setae. *Legs* of ordinary form; posterior femora with a small and rather diffuse patch or brush of small setae.

[1] Part I appeared in *Parasitology*, XVI, p. 55.

Abdomen with the tergites and sternites heavily chitinized and very distinctly defined. Tergites continuous with the pleurites and extending somewhat to the ventral side; posterior margin with a single row of more or less regularly alternating short and long setae; pleural region with several long setae and anterior to these a cluster of short, stout setae. Sternites with

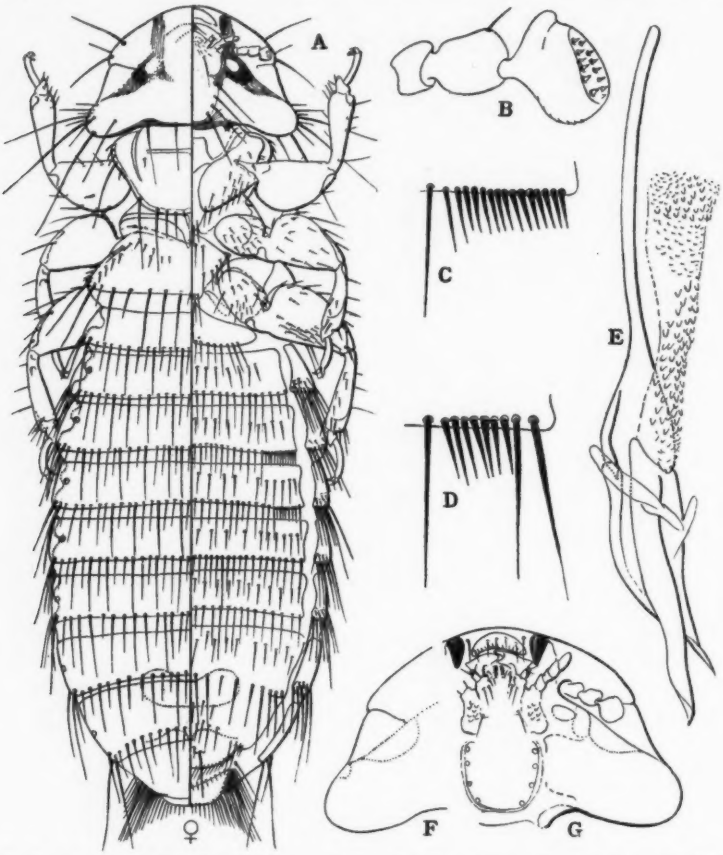

Fig. 6. *Eomenopon denticulatus* Harrison. *A*, female; *B*, antenna; *C*, sternal comb of third abdominal segment; *D*, sternal comb of fourth abdominal segment; *E*, genitalia of male; *F*, outline of dorsal aspect of lateral margin of head; *G*, portion of ventral aspect of head.

two rows of setae, those of the anterior row short and widely spaced, those of the posterior marginal row closely set and at the angles of the third and fourth sternites forming a distinct comb (Fig. 6 *C*, *D*). The large genital plate, which seems to consist of the seventh, eighth and ninth sternites quite closely fused terminates in a broadly rounded flap that is margined with small setae. Within the body is a curious, reniform, chitinized ring of doubtful homology.

The apical sternite forms a rounded flap which bears a closely set fringe of setae, those along the lateral margin being very long. Spiracles very small, present on the third to eighth segments.

Male. In general characters practically identical with the female, differing chiefly in the absence of the terminal sternite with its fringe of long setae and in the slightly different genital plate. *Genitalia* (Fig. 6 *E*) of a very peculiar type; basal plate long and slender, extending forward to the posterior margin of the fourth segment, clavate at its posterior end; preputial sac large, its walls strongly denticulate; articulating to the extremity of the basal plate are a series of very strong, heavily chitinized structures, with the appearance shown in the figure and of doubtful homology.

Note. The original description of this species is quite complete but there are some points, such as the presence of the sternal combs on the third and fourth abdominal segments, which were overlooked and the figures are of the dorsal aspect only. I have consequently dealt with the species here in order that it may be treated uniformly with the others that are to be considered.

(*MS. received for publication* 13. VII. 1925.—Ed.)

ON THE TREMATODE PARASITES OF A WATER-SNAKE, *TROPIDONOTUS PISCATOR.*

By G. D. BHALERAO, M.Sc.

(*Biological Department, University of Rangoon.*)

(With 2 Text-figures.)

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Introduction.

The material for this paper was obtained from snakes, *Tropidonotus piscator*, caught near water pools in Kamayut, Rangoon. Six were dissected, two of which yielded about nine specimens of *Encyclometra bolognensis* (Baer, 1924) from the oesophagus on each occasion. One of them had only one adult and one immature specimen of *Xenopharynx piscator* n.sp. in its gall-bladder. Two others had their intestines infected with numerous specimens of *Acanthochasmus burminis* n.sp. Specimens of *Encyclometra bolognensis* were obtained from grass-snakes, *Tropidonotus natrix*, by Baylis and Cannon and Baer on previous occasions. A different species of *Xenopharynx*, namely *X. solus* Nicoll, 1912, was obtained by Khalil in 1923 and by Nicoll in 1912 from the gall-bladders of Indian cobras, *Naja bungarus* and *Naja tripudians* respectively. It appears, therefore, that the types of the genus *Xenopharynx* are common parasites of the gall-bladders of the Ophidia in the Indian region. Species of *Acanthochasmus* have been previously recorded from reptiles as well as fishes.

I wish here to express my thanks to Prof. F. J. Meggitt for having handed over to me the specimens of *Acanthochasmus burminis* that he obtained during his dissection.

Encyclometra bolognensis (Baer, 1924).

The specimens were obtained on two occasions from the oesophagus of *Tropidonotus piscator*. Each time eight to nine specimens were collected. The anterior part of the worms exhibited very active movements and so could be easily detected. None of them were firmly attached to the host and could thus be easily removed. On examination both in the living condition and in

whole mounts it was found that the worms agreed in all salient features with the description of *Encyclometra natricis* (Baylis and Cannon, 1924, p. 294) and *Odhneria bolognensis* Baer, 1924 (p. 22), the latter declared to be synonyms of *Encyclometra bolognensis* by Baylis and Cannon (1924, p. 558). All the specimens that were obtained were mature except one which will be described presently. The discrepancies that have been pointed out by Baylis and Cannon in Baer's description and which have been admitted by Baer himself are real. In the measurements of suckers, pharynx, testes, ovary, etc. my specimens agree with those of Baylis and Cannon. The shape of the pharynx according to these authors is pear-shaped but this is not true in all cases. There are specimens which have a round pharynx, although not a few of them have a pear-shaped appearance. The oesophagus with its glands is present, but in fixed specimens can easily be passed over on account of its very short length: it can only be seen in forms subjected to pressure. In my specimens its length was 0·075 mm. against 0·038 mm. in those of Baer. As regards the condition of the yolk-glands, in some specimens the follicles are close together, as described by Baylis and Cannon, while in others they are more widely separated as in Baer's description. This fact has already been noted by Baylis and Cannon.

Immature form.

The immature form is pear-shaped, measuring 1·57 mm. long and 0·82 mm. broad, the greatest breadth being at the level of the inter-testicular space. The oral sucker is broader laterally than anteroposteriorly and measures 0·23 × 0·16 mm. The ventral sucker is larger than the oral and measures 0·24 × 0·22 mm. Immediately behind the latter is a prepharynx 0·04 mm. long. The pharynx is broader laterally than anteroposteriorly and measures 0·17 × 0·13 mm. A very short oesophagus can be seen. The intestinal caeca are broad and reach the posterior end of the body: their margins are regular on the inner side, but on the outer are crumpled. This condition does not appear to have been brought about by contraction as the inner margin is straight. The excretory pore is at the posterior end of the body and leads into a very broad and many lobed bladder which passes anteriorly as far as the ovary. From its lateral ends two coiled diverticulae pass as far as the pharynx. The excretory bladder occupies the whole intercaecal area behind the ovary. The testes, 0·16 × 0·075 mm., are situated centrally in the posterior half, one behind the other. The vasa efferentia and the vas deferens could not be seen, but a vesicula seminalis could be made out in the cirrus-sac. The cirrus-sac is pear-shaped and lies anteriorly to the ventral sucker. The ovary is round, situated immediately behind the ventral sucker and measures 0·077 mm. in diameter. Close to its left is the shell-gland. No receptaculum seminis and Laurer's canal could be seen. The yolk-glands are present in a very rudimentary condition: small unitary follicles extending on each side outside the intestinal caeca from behind the posterior border of the ventral sucker to the posterior end of the body. The uterus was not developed.

XENOPHARYNX PISCATOR n. sp.

On one occasion only two specimens were obtained from the gall-bladder of a snake, *Tropidonotus piscator*. One was mature, the other much smaller and quite immature. On examination the mature form was found to agree in some respects with the description of *Xenopharynx solus* given by Nicoll (1912, p. 851), and in others that of the same species given by Khalil (1923, p. 29). The body of the mature worm was almost elliptical, flat and trans-

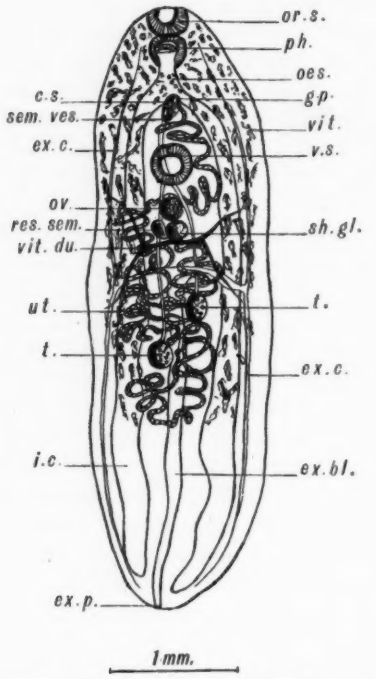

Fig. 1. *Xenopharynx piscator.* *c.s.*, cirrus sac; *ex.bl.*, excretory bladder; *ex.c.*, excretory canal; *ex.p.*, excretory pore; *g.p.*, genital pore; *i.c.*, intestinal caecum; *oes.*, oesophagus; *or.s.*, oral sucker; *ov.*, ovary; *ph.*, pharynx; *res.sem.*, receptaculum seminis; *sem.ves.*, seminal vesicle; *sh.gl.*, shell-gland; *t.*, testis; *ut.*, uterus; *v.s.*, ventral sucker; *vit.*, vitellaria; *vit.du.*, vitelline duct.

parent, so that much of the anatomy could be made out in the living condition under a low magnification upon applying a slight pressure. The worms had no firm attachment to the walls of the gall-bladder and so emerged with the bile that issued upon opening the bladder. The adult form, after being placed in luke warm water, exhibited very sluggish movements. In the living conditions it was 5·5 mm. in length and 1·25 mm. in breadth, but underwent a little contraction during the process of fixation so that the mounted specimen measured 5·01 mm.

long and 1·52 mm. broad, the greatest breadth being at the middle of the body. The whole body is covered with a thin cuticle which is smooth and devoid of either spines or scales. The whole parenchyma is scattered with prominent nuclei.

At the anterior end of the body is the opening of the mouth, 0·11 mm. in diameter, surrounded by an oral sucker more laterally than anteroposteriorly, 0·32 × 0·30 mm. Situated at a distance of 1·33 mm. from the anterior end of the body, *i.e.* near one-fourth of the whole length, is the ventral sucker, measuring 0·33 mm. in diameter. It is circular and only slightly bigger than the oral sucker. In the living condition a short prepharynx was noticed, but in the mounted specimens there was not the least indication of it. Apparently following the oral sucker is a pharynx, broader laterally than anteroposteriorly, 0·31 × 0·25 mm. It is of a peculiar shape, there being a notch at its posterior end for the reception of the anterior portion of the oesophagus. The pharynx thus presents a horse-shoe-like appearance. This condition is not a result of contraction, but a peculiarity of the genus *Xenopharynx* as even in the living condition this state was found to be constant in spite of the alternate contractions and relaxations of the worm. The condition appears to be brought about as has been pointed out by Nicoll (1912, p. 852) by the thinning out of the posterior portion of the pharyngeal wall. The measurements taken at different places of the pharyngeal wall prove this assumption: normally the pharyngeal wall is 0·07 mm. thick, but at the invaginated portion only 0·055 mm. The oesophagus is short, its length, including the portion present in the pharynx is 0·28 mm. and its width is 0·09 mm. It bifurcates into two intestinal caeca which pass along the sides of the body almost to the posterior end. Their course is regular, but behind the level of the posterior testis is slightly sinuous: width of the caeca here is 0·18 mm.

The excretory system is similar to that characteristic of the genus *Erytrema* Looss, 1907. At the posterior end of the body is an excretory pore leading into an excretory vesicle: this enlarges as it passes anteriorly and divides into two branches about half-way between the ovary and the anterior testis. The branches pass obliquely and posteriorly to each side and cross over the intestinal caeca, where each divides into an anterior and a posterior portion, of which the anterior can be traced as far as the posterior end of the pharynx and the posterior almost to the end of the body. The testes are somewhat ovoid bodies, situated diagonally one behind the other in the posterior half of the body. Both are of the same size, 0·20 × 0·17 mm., but the planes of their greater diameter are different, that of the anterior one being at right angles to that of the posterior. The posterior one is at a distance of 0·97 mm. from the posterior end of the body and the anterior 1·09 mm. from it. Both are situated posteriorly to the ovary, the anterior being 0·38 mm. behind it. From their anterior ends, which appear to be slightly drawn out, arise two slightly sinuous vasa efferentia which pass anteriorly, touching the border of the ovary, and fuse with each other on the right posterior border of the ventral

sucker to form a vas deferens. This latter passes dorsally to the ventral sucker and anterior to it enters the cirrus-sac. The vas deferens is very long, the total length being 0·42 mm. After entering the cirrus-sac it enlarges into a curved vesicula seminalis 0·037 mm. wide. The vesicula seminalis soon passes into a ductus-ejaculatorius which opens to the exterior by means of a genital pore situated a little to the left of the intestinal bifurcation. The ductus-ejaculatorius is surrounded by a few unicellular glands, the pars prostatica. Enclosing the vesicula seminalis, ductus-ejaculatorius and pars prostatica is a small cirrus-sac, inclined in an oblique plane from the genital pore. It ends anteriorly to the ventral sucker and is 0·18 mm. long and 0·107 mm. broad. It is wide in front and tapers behind.

The ovary is a perfectly round body, 0·21 mm. in diameter, anterior to the testes, 0·17 mm. behind the ventral sucker and slightly to the right of the middle line. From its posterior end is given out a very short oviduct passing into an ootype surrounded by the shell-gland. This latter, 0·143 × 0·13 mm., lies centrally, immediately behind the ovary. Opening into the ootype from the right side is an oval receptaculum seminis. A Laurer's canal was also observed in the living condition, but in the mounted slide was not visible. The uterus appears to arise from the shell-gland from which it passes posteriorly towards the left in transverse coils, then between the two testes to a distance 1·55 mm. from the posterior end a little behind the posterior testis. Thence its coils pass anteriorly between the testes on the right side to return towards the left anterior to the ovary. Ultimately it opens into the genital pore, coming from the left of the ventral sucker and after describing a few coils in front of it.

All the uterine coils are confined to the intercaecal area, only a few overlapping it. The vitellaria consist of numerous irregular follicles on each side, not very dense, and occupying a large area: they extend from the side of the oral sucker to the posterior termination of the uterine coils. Anteriorly, as far as the intestinal bifurcation, the follicles on each side approximate to each other, but behind the intestinal fork are confined to the extra and super-caecal area. Only in a few cases behind the intestinal fork do the follicles appear in the intercaecal region. Immediately behind the shell-gland were noticed two short transverse vitelline ducts which fuse with each other centrally to form a common vitelline duct opening into the shell-gland. The vitelline ducts on each side are made up of two smaller ducts, one coming from the anterior region and the other from the posterior one. The uterus is filled with yellowish-brown eggs which are operculated at one end and measure 0·037–0·049 × 0·018–0·023 mm.

As has been stated at the outset my specimen resembles in some points that of Khalil and in others that of Nicoll, a comparative table of these three forms would be instructive.

It appears from the following table that in point of the dimensions of the body and general arrangement of the reproductive organs, my specimen agrees with that of Khalil: while in the form of the body, the nature of vesicula

Table I.

A comparative table of the three forms of Xenopharynx.

Species	*Xenopharynx solus* Nicoll, 1912	*Xenopharynx solus* (*fide* Khalil, 1923)	*Xenopharynx piscator* n.sp.
Host	*Naja tripudians*, gall-bladder	*Naja bungarus*, gall-bladder	*Tropidonotus piscator*, gall-bladder
Size	4·55 × 1·68 mm.	5·12 × 2 mm.	5·5 × 1·25 mm.
Shape	Elliptical	Pear-shaped	Elliptical
Cuticle	Smooth	Smooth	Smooth
Oral sucker	0·42 × 0·30 mm.	0·3 × 0·3 mm.	0·32 × 0·3 mm.
Ventral sucker	Diameter 0·41 mm.	Diameter 0·25 mm.	Diameter 0·33 mm.
Pharynx	Peculiar	Ordinary	Peculiar
Oesophagus	Short	Short	Short
Intestinal caeca	Reach posterior end	Reach posterior end	Reach posterior end
Excretory system	Y-shaped	Y-shaped	Eurytrema-like
Testes	Anterior to ovary	Posterior to ovary, in the anterior half of the body	Posterior to ovary, in the posterior half of the body
Cirrus-sac	Small	Not seen	Small
Vesicula seminalis	Convoluted	Not seen	Short and narrow
Ductus-ejaculatorius	Short and narrow	Not seen	Short and narrow
Ovary	Posterior to testes	Anterior to testes	Anterior to testes
Vitellaria	Extending as far as the end of the uterine coils	As far as the middle of the body	As far as the end of the uterine coils
Receptaculum seminis	Not seen	To right of shell-gland	To right of shell-gland
Laurer's canal	Not seen	Not seen	Seen
Genital pore	Over intestinal fork	Over intestinal fork	Over intestinal fork
Eggs	0·036–0·039 × 0·18–0·019 mm. Operculated	0·038 × 0·021 mm. Operculated	0·04–0·044 × 0·017–0·019 mm. Operculated

seminalis, extent of vitellaria, it resembles that of Nicoll. As regards the relative arrangement of the reproductive organs Nicoll's specimens cannot be relied on as he himself has admitted to Khalil that displacement of the organs in question was brought about on account of the maceration which his specimen had undergone. It appears also that Khalil could not obtain a satisfactory mount as he is silent on some points such as vasa efferentia, vesicula seminalis, cirrus-sac, Laurer's canal, etc. In my specimen all the organs show very clearly. Khalil identifies his specimen with *Xenopharynx solus* of Nicoll, but mine differs from them both in the following respects:

(1) Ventral sucker is slightly bigger than the oral.

(2) Excretory system is typically Eurytrema-like.

(3) Testes are situated in the posterior half of the body.

(4) Vitellaria extend on both the sides as far as the posterior extent of the uterus.

These points appear of sufficient importance to justify the creation of a new species for which I propose the name *Xenopharynx piscator*. Although it is inadvisable to propound a new species on the observation of a single specimen, it becomes imperative to do so as, unfortunately, no more specimens were available; moreover, Nicoll had only one specimen at his disposal when he propounded his species—*Xenopharynx solus*.

Khalil has suggested that the genus *Xenopharynx* should be placed in the sub-family Telorchinae instead of Dicrocoelidae: this appears to me unsatisfactory. In the light of the species described here, the genus *Xenopharynx* defined by Khalil (1923, p. 33) requires certain amendments.

Diagnosis. Body elongate and flattened, cuticle without spines. Oral sucker larger or smaller than ventral sucker. Pharynx simple or containing a portion of oesophagus: intestinal caeca simple, long, reaching posterior end of body. Testes diagonal, entire, post-ovarian, in the anterior or posterior half of the body. Ovary inter-caecal, post-acetabular, pre-testicular. Uterus with descending and ascending limbs, inter-caecal, limited to anterior half of the body or extending as far as the extent of the uterine coils. Excretory system Y-shaped or Eurytrema-like.

TYPE SPECIES—XENOPHARYNX SOLUS Nicoll, 1912.

Immature form.

The immature form was also elliptical and measured 1·75 mm. long and 0·57 mm. broad, the greatest breadth being a little behind the ventral sucker. The oral sucker is broader laterally than anteroposteriorly and measures 0·175 × 0·165 mm. The ventral sucker is situated at a distance of 0·72 mm. from the anterior end and measures 0·16 × 0·13 mm. The oral sucker is the bigger of the two. The prepharynx immediately follows the oral sucker. Pharynx is broader laterally than anteroposteriorly, 0·113 × 0·076 mm. Its anterior and posterior parts are very thin, but others are very muscular. Even in immature forms the pharynx contains a portion of the short oesophagus. The intestinal caeca are broad, 0·10 mm., and reach the posterior end of the body: their course is straight and not sinuous posteriorly as in the adult. The excretory system is Y-shaped, the bladder dividing anterior to the testes. The characteristic Eurytrema form of the adult is absent. The testes lie in the posterior half of the body side by side, the left one slightly in advance anteriorly. They are oval, the anterior one measuring 0·083 × 0·072 mm. and the posterior 0·083 × 0·065 mm. It appears from their position that they separate from each other during the development. No vasa efferentia, vas deferens, nor vesicula seminalis were developed. There is a slight indication of the cirrus-sac over the intestinal fork. The ovary is small, oval, 0·047 × 0·42 mm., and situated a little behind the ventral sucker, slightly to the right of the middle line. The shell-gland is situated centrally by the side of the ovary and measures 0·054 mm. in diameter. The receptaculum seminis is not yet developed. Laurer's canal was not seen. The vitellaria, vitelline ducts and uterus also are not developed. In the parenchyma are scattered large nuclei.

ACANTHOCHASMUS BURMINIS n.sp.

On two occasions numerous specimens of this species were obtained from the intestine of *Tropidonotus piscator*. They were not firmly attached to the walls of the intestine so that on placing the opened intestine in a dish of saline solution all of them could be removed. They did not exhibit any active movements. The body of these worms is elongated, cylindrical and so transparent that upon applying but a very slight pressure the whole anatomy can be made

out under a low magnification. The specimens range from 2·13–3·23 mm. in length and from 0·29–0·37 mm. in breadth, the maximum breadth being attained at the level of the ventral sucker: from here the body tapers both ways; there is sometimes a slight bulging in the region of the gonads, situated a little in front of the posterior end. The whole body is covered with an armature

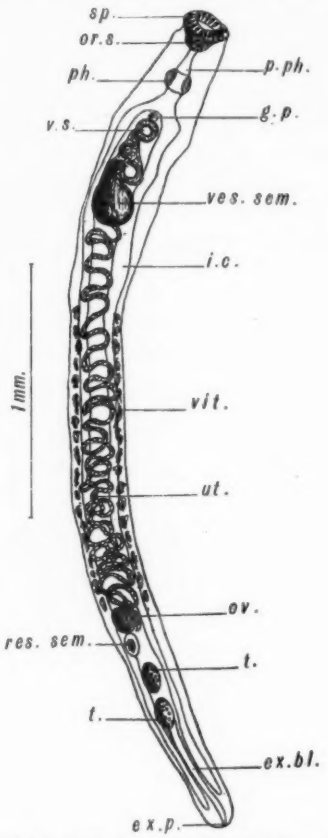

Fig. 2. *Acanthochasmus burminis*. *ex.bl.*, excretory bladder; *ex.p.*, excretory pore; *g.p.*, genital pore; *i.c.*, intestinal caecum; *or.s.*, oral sucker; *ov.*, ovary; *ph.*, pharynx; *p.ph.*, pre-pharynx; *res.sem.*, receptaculum seminis; *sp.*, spine; *t.*, testis; *ut.*, uterus; *ves.sem.*, seminal vesicle; *v.s.*, ventral sucker; *vit.*, vitellaria.

of spines which are very dense anteriorly, but becoming sparser behind the level of the ovary. They are placed anteriorly on cuticular blocks, 0·003–0·005 mm. in size. They are directed backwardly and are disposed in obliquely transverse rows.

The opening of the mouth is surrounded by an oral sucker, 0·16 × 0·13 mm., broader laterally than anteroposteriorly. It bears a single row of spines,

0·028–0·04 mm. long and 0·012–0·024 mm. thick, the number of which varies from 24 to 27. Situated at a distance of nearly one-fifth the whole length of the body from the anterior end is the ventral sucker measuring 0·07–0·08 mm. in diameter: it is circular and smaller than the oral sucker. The ratio they bear towards each other is 2 : 1.

Following the oral sucker is a prepharynx 0·08 mm. in length, followed by a muscular pharynx which appears square in preserved specimens and measures 0·08 × 0·08 mm. Behind it is a short but wide oesophagus, 0·04 × 0·06 mm., soon bifurcating into two intestinal caeca which pass posteriorly almost to the end of the body. They are simple with thin walls and their width is about 0·03 mm.

The excretory pore is situated at the posterior end of the body. It leads into an excretory bladder passing anteriorly as far as the anterior border of the ovary, where it divides into two excretory canals which pass anteriorly along the sides of the body and end at the level of the pharynx.

The testes lie one behind the other in the same line in the posterior part of the body and are situated behind the ovary. Usually they are oval, but in the specimens submitted to a little pressure appear to be round. They measure 0·085–0·19 × 0·07–0·17 mm. Neither vasa efferentia nor the vas deferens could be traced. Vesicula seminalis is voluminous and lies free in the parenchyma, extending about 0·32 mm. posterior to the ventral sucker. It consists of a big sac, 0·13 × 0·13 mm. posteriorly, and an anterior coiled portion which becomes ultimately converted into a muscular ductus-ejaculatorius opening to the exterior by means of a genital pore. This latter is situated about 0·43 mm. from the anterior end immediately in front of the ventral sucker, between it and the intestinal fork. Surrounding the ductus-ejaculatorius and opening into it are numerous unicellular glands, the pars prostatica.

The ovary is an oval body lying anteriorly to the testes in the posterior part of the body. It is situated centrally and measures 0·11–0·14 × 0·07–0·14 mm. Posteriorly it gives out a very small oviduct which opens into an ootype surrounded by the shell-gland. Opening also into the ootype from its left side is a receptaculum seminis, 0·07–0·09 × 0·06–0·07 mm. In the living condition the movement of the spermatozoa in the receptaculum seminis can be easily seen under low magnification. On the same side is a Laurer's canal which passes dorsally to open on the integument: it is appreciably wide so that it can easily be noticed even in the living condition. The uterus starts from behind the ovary and passes anteriorly, describing many transverse coils between the ovary and the posterior end of the vesicula seminalis. Further, it passes almost parallel to the vesicula seminalis and opens into the genital pore from the right side of the ventral sucker. No ductus hermaphroditicus was noticed. The vitellaria start from approximately 0·30 mm. behind the posterior end of the vesicula seminalis and extend as two parallel lines posteriorly as far as the ovary: mostly they lie outside the intestinal caeca, only in a few cases do the follicles cross them. Two vitelline ducts approximate in the middle line behind

the ovary. The uterus is filled with numerous yellowish-brown eggs which measure 0·017–0·027 × 0·042–0·06 mm. and are operculated at one end.

The present species resembles *Acanthochasmus spiniceps* (Looss, 1896), *A. vicinis* Odhner, 1902, *A. scyphocephalus* (Braun, 1899), *A. coronaris* (Cobbold, 1861), *A. absconditus* Looss, 1901, and *A. productus* Odhner, 1902, in the general shape of the body, the coiled nature of the vesicula seminalis, the uterus not extending beyond the testes, and the receptaculum seminis being situated behind the ovary. In the anterior extent of the vitellaria it resembles *A. productus* Odhner, 1902, *A. absconditus* Looss, 1901, and *A. imbutiformis* (Mol, 1859). The ratio of the suckers agrees more with that of *A. absconditus* Looss, 1901, *A. vicinis* Odhner, 1902, and *A. productus* Odhner, 1902. But it differs from all others in the following points:

(1) The uterine coils ending at the anterior end of the ovary.
(2) The vitellaria also ending at the anterior end of the ovary.
(3) The receptaculum seminis being very large.
(4) The ratio of the oral to the ventral sucker being 2 : 1.

These points are of sufficient importance for the creation of a new species for which I propose the name *Acanthochasmus burminis*.

Specific Diagnosis—Acanthochasmus.

Body elongated, round. Cuticle beset with spines. Oral sucker twice as large as the ventral and possessing 24–27 spines. Pharynx muscular. Prepharynx present. Oesophagus short and wide. Intestinal caeca reach the posterior end of the body. Excretory system Y-shaped. Testes in posterior part of the body behind ovary, one behind the other, round to oval. Vesicula seminalis free in parenchyma, voluminous, coiled, extending posterior to ventral sucker. Pars prostatica and ductus-ejaculatorius present. Ovary anterior to testes in the posterior half of the body. Shell-gland posterior to ovary. Receptaculum seminis large. Laurer's canal present. Uterus long, containing large eggs, coils between ovary and posterior end of vesicula seminalis. Vitellaria extending along the sides of the body, anteriorly not reaching posterior end of vesicula seminalis, and posteriorly not extending beyond ovary. Eggs yellowish-brown, operculated, 0·04–0·06 × 0·017–0·027 mm.

Host: *Tropidonotus piscator*.

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A REFERENCE LIST OF THE TREMATODE PARASITES OF BRITISH AMPHIBIA.

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Introduction.

In spite of the fact that frogs form a common subject of biological examination and experiment it is curious that, in this country, there have been few reports on the helminth parasites with which they are so frequently infected. We owe practically all our knowledge of the Trematode parasites of amphibians to continental zoologists. The early researches of von Frölich (1789–1802) and Rudolphi (1809) followed, a hundred years later, by those of von Linstow (1877–1890) and Looss (1894–1901), are responsible for the greater part of the existing information. Amongst others who have devoted some attention to the subject may be mentioned the names of Dujardin (1845), Diesing (1836–1858), Gastaldi (1854) and Olsson (1876).

The two most generally useful works on the subject are undoubtedly Looss's *Die Distomen unserer Fische und Frösche* and Lühe's "Trematodes" in Brauer's *Die Süsswasserfauna Deutschlands*, to which reference should, in every case, be made.

Lengthy comment on the subjoined lists appears unnecessary, but attention may be drawn to the extraordinary variety of Trematode parasites which may infest the common and edible frogs and to the remarkable number of species which occur in the lungs and urinary bladder. The edible frog, indeed, appears to be subject to a greater variety of Trematode infection than any other British vertebrate, displaying as it does even greater diversity of infection than the dog, the cat or the ox. The records from the common frog are not quite so numerous.

Considering the zoological position of Amphibia one would anticipate that their parasites would show more or less relationship to those of reptiles on the one hand and fresh-water fishes on the other, and such, in fact, is the case. Of the five families of Distomate Trematodes found in Amphibia, four also have representatives amongst reptiles and one (Gorgoderidae) amongst fishes. The common monogenetic *Polystoma* of the frog also bears obvious relationship to the large class of monogenetic parasites of fishes.

The only two genera which are common to British frogs and reptiles are *Brachycoelium* and *Cephalogonimus*. The record of a species of *Plagiorchis* from the common frog is open to doubt.

LIST OF THE TREMATODE PARASITES OF BRITISH AMPHIBIA, ARRANGED SYSTEMATICALLY.

Order **DIGENEA.**

Super-family DISTOMATA.

Family PLAGIORCHIDAE Lühe (LEPODERMATIDAE Odhner).

	AUTHORITY
Genus *Opisthioglyphe* Looss 1899	
1. O. ranae (Froelich)	v. Linstow 1887, Looss 1894
[= O. endoloba (Duj.)]	
2. O. hystrix (Molin)	Molin 1861, Olsson 1876, Looss 1907
[= O. rastellus (Olss.)]	
Genus *Pneumonoeces* Looss 1902	
3. P. variegatus (Rud.)	Looss 1894, Lühe 1909
4. P. asper Looss	Looss 1899, Wundsch 1911
5. P. similigenus St. and H.	Looss 1899, Stiles and Hassall 1902
[= P. similis Lss.]	
Genus *Haplometra* Looss 1899	
6. H. cylindracea (Zed.)	v. Linstow 1890, Looss 1894
Genus *Plagiorchis* Lühe	
[= *Lepoderma* Looss]	
7. P. mentulatus (Rud.)	Stossich 1889, Mühling 1898

Family DICROCOELIIDAE Odhner.

Genus *Brachycoelium* Dujardin 1845	
8. B. salamandrae (Froel.)	Looss 1894, Odhner 1910
[= B. crassicolle (Rud.)]	
Genus *Brandesia* Stossich 1899	
9. B. turgida (Brandes)	Willem 1906, Mühling 1898, Looss 1899

Family LECITHODENDRIIDAE Odhner.

Genus *Pleurogenes* Looss 1896	
10. P. claviger (Rud.)	Looss 1894, Lühe 1909
11. P. medians (Olss.)	Olsson 1876, Looss 1894, 1896, Stossich 1900
[= D. tacapense Sonsino]	
Genus *Prosotocus* Looss 1899	
12. P. confusus Lss.	Looss 1894, 1898, Lühe 1909

Family GORGODERIDAE Looss.

Genus *Gorgodera* Looss 1899	
13. G. cygnoides (Zed.)	Wagener 1857, Looss 1894
14. G. pagenstecheri Ssin.	Pagenstecher 1857, Ssinitzin 1905
15. G. varsoviensis Ssin.	Ssinitzin 1905, Lühe 1909
Genus *Gorgoderina* Looss 1902	
16. G. vitelliloba (Olss.)	Looss 1902, Ssinitzin 1905, Lühe 1909

Family PROSTHOGONIMIDAE Lühe.

(= CEPHALOGONIMIDAE Looss.)

	AUTHORITY
Genus *Cephalogonimus* Poirier 1886	
17. C. europaeus Blaizot	Blaizot 1910
18. C. retusus (Duj.)	Dujardin 1845, Odhner 1910

Unclassified Genera.

Genus *Halipegus* Looss 1899	
19. H. ovocaudatus (Vulpian)	Looss 1894, Lühe 1909
Genus "*Eurysoma*" Dujardin 1845[1]	
20. E. squamula (Rud.) larva	Fraipont 1880, Lühe 1909
Genus "*Brachymetra*" Stossich 1894[1]	
21. B. parva Stossich	Stossich 1894

Unclassified Species.

22. Distomum acervocalciferum Gastaldi	Gastaldi 1854, Rizzo 1902
23. D. bufonis Linst. (larva)	v. Linstow 1877, Braun 1893
24. D. diffusocalciferum Gastaldi	Gastaldi 1854, Braun 1893
25. D. depressum (Polon.) Parona	Braun 1892, Parona 1894
26. D. gyrini Linst. (larva)	v. Linstow 1884, Lühe 1909
27. D. incistidatum (Perroncito) (larva)	Perroncito 1880, Ercolani 1882
28. D. wedlii Cobbold [= D. Pelophylacis esculenti Wedl.]	Wedl 1849, Cobbold 1860, Braun 1893
29. D. (Cystagora) tetracystis Gastaldi	Gastaldi 1854, Filippi 1854
30. Cercaria micracantha Diesing	Diesing 1858, v. Linstow 1887

Super-family AMPHISTOMATA.

Genus *Diplodiscus* Diesing 1836	
31. D. subclavatus (Pallas) [= D. unguiculatus Dies.]	Diesing 1836, Wagener 1857
Genus *Opisthodiscus* Cohn 1904	
32. O. diplodiscoides Cohn	Cohn 1904, Lühe 1909

Super-family HOLOSTOMATA.

Genus *Tylodelphys* Diesing 1850	
33. T. rhachiaea (Henle) [= T. rhachidis Dies.]	Diesing 1850, Pagenstecher 1857
Genus *Tetracotyle* Filippi 1854	
34. T. crystallina (Rud.)	v. Linstow 1877, Faust 1918
Genus *Codonocephalus* Diesing 1850	
35. C. urniger (Rud.) [= C. mutabilis (Dies.)]	Gastaldi 1854, Molin 1859, Kopczynski 1907

Order **MONOGENEA.**

Family POLYSTOMIDAE.

Genus *Polystoma* Zeder 1800	
36. P. integerrimum (Froel.)	Rudolphi 1809, Stieda 1871, Zeller 1872, Goldschmidt 1902

[1] These generic names are preoccupied.

LIST OF THE TREMATODE PARASITES OF BRITISH AMPHIBIA, ARRANGED ACCORDING TO THEIR HOSTS.

URODELA

1. *Molge cristata* Laur. Crested newt

Opisthioglyphe ranae (Froel.)	Intestine
Brachycoelium salamandrae (Froel.)	Intestine
Distomum depressum Pol.	Intestine

2. *Molge vulgaris* Linn. Common newt

Brachycoelium salamandrae (Froel.)	Rectum
Pleurogenes claviger (Rud.)	Intestine
Cercaria micracantha Dies.	Skin in cysts
Diplodiscus subclavatus (Pall.)	Rectum

3. *Molge palmata* Schneid. Palmated newt

Nil.

ANURA

4. *Rana esculenta* Linn. Edible frog

Opisthioglyphe ranae (Froel.)	Intestine
Opisthioglyphe hystrix (Molin)	Intestine
Pneumonoeces variegatus (Rud.)	Lungs
Pneumonoeces asper Looss	Lungs
Pneumonoeces similigenus St. and H.	Lungs
Haplometra cylindracea (Zed.)	Lungs
Brandesia turgida (Brds.)	Pylorus, in Lieberkühn's follicles
Pleurogenes claviger (Rud.)	Intestine
Pleurogenes medians (Olss.)	Intestine
Prosotocus confusus Lss.	Intestine
Gorgodera cygnoides (Zed.)	Urinary bladder
Gorgodera pagenstecheri Ssin.	Urinary bladder
Gorgodera varsoviensis Ssin.	Urinary bladder
Gorgoderina vitelliloba (Olss.)	Urinary bladder
Cephalogonimus europaeus Blaiz.	Intestine
Cephalogonimus retusus (Duj.)	Intestine
Halipegus ovocaudatus (Vulpian)	Mouth, under tongue
Brachymetra parva Stoss.	Encysted in muscles
Distomum acervocalciferum Gast.	Encysted in nerves
Distomum diffusocalciferum Gast.	Encysted in skin, muscles, liver and lungs
Distomum incistidatum (Perronc.) (larva)	In cysts
Distomum (Cystagora) tetracystis Gast.	Encysted in muscles
Distomum wedlii Cobb.	Brain
Diplodiscus subclavatus (Pall.)	Rectum
Opisthodiscus diplodiscoides Cohn	Rectum
Tylodelphys rhachiaea (Henle)	Cerebrospinal fluid
Tetracotyle crystallina (Rud.)	Peritoneum in cysts
Codonocephalus urniger (Rud.)	Peritoneum in cysts
Polystoma integerrimum (Froel.)	Urinary bladder

5. *Rana temporaria* Linn. Common frog

Opisthioglyphe ranae (Froel.)	Intestine
Opisthioglyphe hystrix (Molin)	Intestine
Pneumonoeces variegatus (Rud.)	Lungs

ANURA (*cont.*).

5. *Rana temporaria* Linn. Common frog (*cont.*)

Haplometra cylindracea (Zed.)	Lungs
? Plagiorchis mentulatus (Rud.)	Intestine
Brachycoelium salamandrae (Froel.)	Intestine
Pleurogenes claviger (Rud.)	Intestine
Pleurogenes medians (Olss.)	Intestine
Prosotocus confusus Lss.	Intestine
Gorgodera sygnoides (Zed.)	Urinary bladder
Gorgodera pagenstecheri Ssin.	Urinary bladder
Gorgodera varsoviensis Ssin.	Urinary bladder
Gorgoderina vitelliloba (Olss.)	Urinary bladder
Cephalogonimus retusus (Duj.)	Intestine
Halipegus ovocaudatus (Vulp.)	Mouth
Eurysoma squamula (Rud.)	Encysted in skin
Distomum gyrini Linst.	Encysted in tadpole
Diplodiscus subclavatus (Pall.)	Rectum
Tylodelphys rhachiaea (Henle)	Encysted in spinal cord and intestine
Tetracotyle crystallina (Rud.)	Encysted in peritoneum
Polystoma integerrimum (Froel.)	Urinary bladder

6. *Bufo vulgaris* Laur. Common toad

Opisthioglyphe ranae (Froel.)	Intestine
? Pneumonoeces variegatus (Rud.)	Lungs
Haplometra cylindracea (Zed.)	Lungs
Brachycoelium salamandrae (Froel.)	Intestine
Pleurogenes claviger (Rud.)	Intestine
Pleurogenes medians (Olss.)	Intestine
Prosotocus confusus Lss.	Intestine
Distomum bufonis Linst. (larva)	Encysted in peritoneum
Diplodiscus subclavatus (Pall.)	Rectum

7. *Bufo calamita* Laur. Natterjack toad

Opisthioglyphe ranae (Froel.)	Intestine
Pleurogenes claviger (Rud.)	Intestine
Pleurogenes medians (Olss.)	Intestine
Prosotocus confusus Lss.	Intestine

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SOME BRITISH FRESHWATER LARVAL TREMATODES WITH CONTRIBUTIONS TO THEIR LIFE HISTORIES.

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(With Plates I—III, including 30 Figures.)

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I. Introduction.

Although, in the early part of the nineteenth century, a considerable amount of work on larval trematodes was done on the continent by von Siebold (1835), de Fillippi (1855) and La Valette (1855), so far as I know, no similar work was undertaken in this country. It was not until 1880, when a great controversy raged round the intermediate host of the liver fluke, that any interest was aroused. This culminated in 1883 with the publication, by Thomas, of the life history. Thomas also discovered that *Limnaea peregra* was infected with cercariae different from those of the liver fluke. Since that time the interest has lapsed, and, excluding a description of two cercariae by Hesse (1923), I do not know of any published records of work on freshwater larval trematodes of this country. On the other hand, work on the continent and in America has increased, and although our knowledge of the life histories of trematodes is still in its infancy, a considerable number of continental larval forms have been found and described. However, Lebour (1905) commenced a study of *marine* larval trematodes and together with Nicoll (1906) attempted to establish life histories.

The following work, which is confined to freshwater larval trematodes, was commenced in the Zoology Department of the University of Birmingham under Prof. Gamble, F.R.S., to whom I am greatly indebted for considerable help and advice. It has been continued in Leeds and it is becoming evident that the freshwater larval trematode fauna of this country is as extensive as

that of the continent. In this paper I have brought together 9 species (7 of which are new) which parasitise the freshwater molluscs *Limnaea stagnalis* and *Limnaea peregra*. From the beginning attempts have been made to establish life histories, the most difficult part of the work, but considerable evidence has been obtained, the confirmation of which is only a matter of time.

II. Infection.

It is very difficult to estimate the effect of these parasites on their host; that they are harmful is indisputable. The digestive gland usually looks unhealthy, particularly in infections of Echinostome and stylet cercariae. The gonad, however, is rarely infected. Observations in aquaria are of little use, since the conditions are far from natural, but it is noticeable that molluscs infected with Echinostome or stylet cercariae die sooner than those infected with fork-tailed cercariae. Lebour (1912) states that the presence of rediae certainly injures the molluscan host, but the presence of cysts, even in great numbers, seems to do little or no harm. The same I have found to be true of freshwater larval trematodes.

In some cases, double infection may occur in the same individual. Sewell (1912) states that in India double infection is rare, but Faust (1917) in America found several instances of it. According to Faust (1917) Ssintzin, who examined several thousand snails, made no record of double infection. So far I have not found any examples of double infection in the Leeds district, but the following have been found in the neighbourhood of Birmingham.

Three examples of *Cercaria pseudarmata* n.sp. and *Cercaria fissicauda* (La Val) in *Limnaea stagnalis*.

One example of *Cercaria pseudarmata* n.sp. and *Cercaria equispinosa* n.sp. in *Limnaea stagnalis*.

Two examples of *Cercaria echinata* von Sieb. and *Cercaria equispinosa* n.sp. in *Limnaea stagnalis*.

No instances of double infection have been found in *Limnaea peregra*. The cysts are often found associated in the same individual, particularly in the case of Echinostome cercariae. Although there is reason to believe that the intermediate host is not always specific (Lühe, 1909; Faust, 1917; Cort, 1918; Taylor, 1923) I have not found any examples of non-specificity up to the present. Cort (1918) also states that fork-tailed cercariae readily adapt themselves to new molluscan hosts.

III. Echinostome Cercariae.

These cercariae may be distinguished from all others by the presence of a collar of spines surrounding the anterior end of the body. They develop in rediae and encyst in a second intermediate host. This host is usually a mollusc and very often the same species as the first.

Cercaria echinata von Siebold.

(Plate I, figs. 1–6.)

C. echinata develops in elongate, orange coloured rediae which are capable of independent movement, in the digestive gland of *Limnaea stagnalis*. A fairly well-marked collar and ambulatory processes are present. The short sac-like intestine extends just beyond the collar. A group of flame cells is situated near the ambulatory processes, but it has not yet been possible to trace the ducts leading from them. The rediae vary considerably in size from 0·71 mm. to 3·5 mm. long. The cercaria, which is comparatively large, measures from 0·585 mm.–0·702 mm. in length. The slender tail, which is slightly longer than the body, is 0·76 mm. long, and 0·105 mm. wide at its junction with the body. The latter is covered with spines, except at the posterior end. At the head end is a distinct collar which bears a double row of 37 spines. The collar is continuous on the dorsal surface, but on the ventral surface its edges turn inwards towards the oral sucker. Viewed from the ventral surface the collar appears as two ventro-lateral lappets on either side of the pharynx. Of the 37 spines, 8 are larger than the rest. They are situated in two groups of 4 each on the inner edge of the "lappets" of the ventral surface of the collar. The region between these two groups is devoid of spines. The well-developed oral sucker has a diameter of 0·064 mm., whilst the larger heart-shaped ventral sucker, situated well behind the middle of the body, is 0·10 mm. long and 0·096 mm. wide. The prepharynx is short, pharynx well developed, oesophagus long, and the intestinal caeca extend to the posterior end of the body. Round the mouth-opening in the middle of the oral sucker are the openings, twelve in number, of ducts leading from gland cells, which are distributed throughout the anterior region of the body; their structure being obscured by overlying cystogenous gland cells which extend throughout the whole body. The excretory system is bilaterally symmetrical. On each side, a duct arises from 3 flame cells near the oral sucker, and passes back, receiving on its way the ducts from many flame cells, until it reaches the posterior end of the body, where it loops back upon itself and passes forward again to the level of the pharynx. Here it again forms a loop, then considerably widened, it passes back, as the main excretory canal, dorsal to the ventral sucker, to the posterior end of the body, where it unites with the main canal from the other side; the combined canals leading into a large round excretory vesicle. From this vesicle a duct passes down the tail, for a sixth of its length, when it bifurcates, each fork passing to the lateral edge of the tail. The main canals in the anterior region of the body are full of clear spherical granules. Altogether there are 86 flame cells in the body, 43 on each side, but it is impossible, owing to the dense overlying cystogenous gland cells, to trace out their fine connecting ducts. The genital system is represented by 3 masses of small round cells, one just in front and round the margin of the ventral sucker, and the other two between the sucker and the excretory vesicle.

The cercaria leaves its host, swims about, and enters another individual of the same species in order to encyst. The cysts are found near the salivary gland and oesophagus (usually on the left side) of *Limnaea stagnalis*, *Limnaea peregra*, and also in the mantle of *Sphaerium corneum*. I have also found the cysts in *Viviparus viviparus* from a pond near Leeds. The thick walled spherical cysts are 0·24 mm. in diameter and the young trematode is curled up inside, so that its ventral anterior surface is opposed to the ventral posterior surface, the oral sucker touching the tip of the posterior extremity. The young worm, when removed from the cyst, is 0·71 mm. long and 0·16 mm. wide. The collar is well marked and the spines are much larger than in the cercaria. The 29 equal spines are 0·039 mm. long, and 0·006 mm. wide, whilst the remaining 8 larger spines measure 0·045 mm. × 0·009 mm. The oral sucker is 0·064 mm. across and the ventral sucker, now situated in front of the middle of the body, is 0·12 mm. across. The intestinal caeca are considerably developed and extend to the posterior region of the body. The excretory and genital systems also show a marked development. The testes lie exactly one behind the other in the posterior region of the body, whilst the ovary is anterior to them, and signs of a cirrus sac appear in front and to the side of the ventral sucker. The worm now bears a remarkable resemblance to *Echinostomum revolutum* (Frölich) and evidence suggested the mallard, *Anas boschas*, as the final host. A young mallard, which had been reared on a pond where 95 per cent. of the *Limnaea stagnalis* were infected with *C. echinata* and cysts, was obtained, and although 5 Echinostomes were found in the intestine, they were immature and very little further advanced than those obtained from cysts, with which they were almost identical. In the worms obtained from the young mallard, the vitellaria had begun to appear as rosette shaped follicles on either side of the body between the ventral sucker and the posterior extremity. Apart from this and the more pronounced cirrus sac, the worms were identical. In the literature on the subject, the life history of *Echinostomum revolutum* Fröl. has caused a great deal of confusion. Dietz (1910), the latest authority on Echinostomes of birds, says nothing of the life history, but Lühe (1909) says that the larva appears to be one encysted in *Pisidium fossarinum* and gives measurements of the cysts (0·17 mm.) which do not correspond with those given above. He also states that it is impossible to infect ducks with these cysts from *Viviparus viviparus*. I have no doubt that *C. echinata* is the larva of *Echinostomum revolutum* Froël., but with a view to the complete elucidation of the life history attempts are being made to obtain, experimentally, all stages from the egg onwards.

Cercaria granulosa n.sp.

(Plate I, figs. 7–10.)

C. granulosa develops in rediae in the digestive glands of *Limnaea peregra*. These rediae differ from those of *C. echinata* in that the majority are white, or at most a very pale yellow. The collar region and birth-pore are well

marked, but the ambulatory processes, which are very distinct in young rediae, are considerably reduced and often absent in the older ones. Two distinct spherical excretory vesicles are situated just in front of the ambulatory processes, and lateral anterior and posterior excretory ducts empty into them. Many flame cells are scattered throughout the body in this region, but it is impossible to trace their fine connecting ducts. No excretory pore can be seen in the excretory vesicles. The club-shaped intestine is very short and does not extend beyond the collar region. The rediae vary considerably in size from 0·53 mm. to 2·1 mm. in length.

The shape of the cercaria, as well as its movements, are typical of the Echinostomes. In swimming the body is continually bent ventralwards into a U, the oral sucker opposed to the posterior body extremity, and then straightened out again. The cercaria is 0·351 mm. to 0·40 mm. long: the tail, which is slightly shorter than the body, is 0·315 mm. in length. The tail extremity is peculiar and reminiscent of *C. purpurae* Lebour (1912), which has a sucker-like extremity. In *C. granulosa* the extremity is capable of being withdrawn a short distance into the tail stem, and though this gives the tip of the tail a sucker-like appearance, I have not seen it used as a sucker. The anterior region of the body is armed with transverse rows of small spines, whilst the collar carries a double row of 39 (?) feebly developed spines. The oral sucker is 0·057 mm. in diameter, and the larger ventral sucker, situated well behind the middle of the body, is 0·076 mm. × 0·065 mm. The alimentary canal is similar to other Echinostome cercariae, though the clear spherical granules are absent. The excretory system, however, shows marked differences, the chief of which is the appearance of the wide anterior region of the main lateral canals. These are packed with numerous tiny spherical granules. There is no excretory duct in the tail. The bilaterally symmetrical excretory system arises as a duct from 3 flame cells near the oral sucker, passes back to the posterior end of the body, almost parallel to the side, forms a loop and returns to the anterior region to loop again and then widen out considerably to form the main lateral canal. This then passes, dorsal to the ventral sucker, to the posterior region of the body, where it joins its fellow of the other side, the combined canals leading into a fairly large round excretory vesicle. A small excretory pore is situated slightly dorsal to the posterior end of the excretory vesicle. Altogether there are 24 flame cells, 12 on each side of the body, but the cystogenous gland cells, lying beneath the cuticle in the posterior two-thirds of the body, obscure their fine connecting ducts. The genital system is represented by a mass of cells lying between the ventral sucker and the posterior end of the body.

The cercaria encysts near the salivary glands of *Limnaea peregra*, and in ponds inhabited by *Limnaea stagnalis* infected with *C. echinata* and *Limnaea peregra* infected with *C. granulosa*, the cysts of both species are found associated in *Limnaea peregra*, but so far I have not found them associated in *Limnaea stagnalis*. *C. granulosa* also encysts in the mantle of *Sphaerium corneum*.

The spherical cysts have a diameter of 0·163 mm. The young worm when removed from the cyst, unlike *C. echinata*, shows very little, if any, further development than the cercaria. This may be due to the fact that the cysts were obtained during the summer months, for generally cysts which have passed a winter in their host show a greater development than those obtained in the summer, when they have only just encysted. The spines, too, are still feebly developed. *C. granulosa* evidently belongs to the genus Echinostomum, and evidence suggests that either the mallard, *Anas boschas*, or the plover, *Vanellus vanellus*, is the final host.

Cercaria equispinosa n.sp.

(Plate II, figs. 11–13.)

I have only found this cercaria twice and on each occasion it was associated with *C. echinata* in the digestive gland of *Limnaea stagnalis*. Indeed *C. equispinosa* is extremely like *C. echinata*, the only apparent difference being in point of size. The redia in which it develops however is easily distinguishable from that of *C. echinata*. The pharynx is very small (0·06 mm.) and the sac-like intestine extends beyond the collar region. Birth-pore and ambulatory processes are present. The largest redia was 3·04 mm. long and 0·3 mm. wide. *C. equispinosa* is 0·293 mm. long and possesses a distinct collar carrying a row of 37 (?) spines. These are all of the same size. The anterior half of the body is covered with transverse rows of minute spines. The slender tail (0·351 mm.) is longer than the body. The well-developed oral sucker has a diameter of 0·04 mm. and is smaller than the round ventral sucker, 0·055 mm. across, situated behind the middle of the body. The oral sucker is followed by a short prepharynx, well-developed pharynx, long oesophagus and intestinal caeca extending to the posterior end of the body. The oesophagus and caeca are filled with a single row of clear spherical granules. Short ducts from salivary gland cells open by twelve small pores round the oral sucker. The cystogenous gland cells, which fill the whole body, obscure the salivary gland cells. The excretory system is bilaterally symmetrical and arranged on a similar plan to that of *C. echinata*, though no posterior loop could be made out. The duct from the three flame cells near the oral sucker also appears to join the accessory lateral duct. Several flame cells (4) are present on each side of the posterior region of the body. I was not able to work out the complete excretory system in the few cercariae at my disposal. There is a distinct excretory vesicle with a short duct passing down the tail stem and bifurcating, each duct then passing to the opposite lateral margins of the tail. A mass of small round cells lying between the ventral sucker and the excretory vesicle represent the rudiments of the genital system. After swimming about, the cercaria encysts near the salivary glands and the external wall of the oesophagus of its first host, *Limnaea stagnalis*, and is generally associated with the cysts of *C. echinata*. Cysts of *C. equispinosa* have also been found in the mantle of *Ancylus lacustris*. Usually there is only one cyst in each *Ancylus*

and never more than three. The thick-walled cyst has a diameter of 0·159 mm. So far I have been unable to open the cyst, on account of its small size and thick resistant walls. The final host is unknown, though evidence suggests, as does the association of the cysts with those of *C. echinata*, that it is the mallard, *Anas boschas*.

IV. "Stylet" Cercariae (Xiphidiocercariae).

The body of the members of this group possesses a rounded anterior end, which is armed with a stylet, situated dorsal to the oral sucker. The tail is usually slender. "Stylet" cercariae develop in sporocysts and encyst in a second intermediate host, which is usually an Arthropod.

Cercaria pulicis n.sp.

(Plate II, figs. 14–18.)

This cercaria is fairly common in the streams of both the Birmingham and the Leeds districts. It develops in short, usually S-shaped sporocysts about 1 mm. long, in the digestive gland of *Limnaea peregra*. The sporocysts are white, incapable of independent movement and do not possess a birth-pore. The cercaria, which is extremely active, is 0·292 mm. long, and the tail, set in a groove, known as the caudal pocket, on the ventral surface of the posterior end of the body, is slightly shorter than the body, its length being 0·234 mm. The body is covered with transverse rows of minute spines. Cystogenous glands are situated beneath the cuticle of the posterior two-thirds of the body. A strong "stylet" or boring spine 0·032 mm. long lies dorsal to the anterior sucker. At a point, about a third of its length from the anterior end of the spine, is a well-marked shoulder 0·009 mm. across. The oral sucker is well developed, 0·072 mm. in diameter, whilst the ventral sucker, situated behind the middle of the body, is only half the size of the oral sucker, its diameter being 0·035 mm. The prepharynx is short, pharnyx well-developed, oesophagus long, and the intestinal caeca do not extend to the posterior end of the body, but end just beyond the ventral sucker. Stylet glands consist of four pairs of cells situated in two groups, slightly anterior and lateral to the ventral sucker. The ducts arising from them pass forwards and open in two groups of four each on either side of the stylet. The excretory system comprises anterior and posterior lateral ducts, which unite near the ventral sucker to form two main collecting canals which lead into a round excretory vesicle at the posterior end of the body. The anterior lateral duct receives accessory ducts from two groups of three flame cells each; one group is situated near the oral sucker and pharynx and the other near the ventral sucker. Midway between these two groups, a duct enters from a single flame cell situated near the oesophagus. The posterior lateral duct receives accessory ducts from two groups of three flame cells in the posterior region of the body. Altogether, there are 26 flame cells, 13 on each side of the body and arranged in the following order from the anterior end (3 + 1 + 3) + (3 + 3). The

genital system rudiment is represented by a large mass of small cells distributed round the right side (ventral view) of the ventral sucker, and dorsal to it. The cercaria leaves its host and swims about until it finds its second intermediate host, *Gammarus pulex*. It attaches itself to the body of the shrimp and crawls, using both suckers, by looping movements until it reaches a joint between two body segments, usually in the mid-dorsal region. With the aid of the stylet it enters the body, losing its tail in the process. Eventually it reaches the walls of the hepatic caeca, where it encysts. There are rarely more than 10 cysts in an infected Gammarus, though on a few occasions I have found as many as 34. Female freshwater shrimps are usually more heavily infected than males. The cysts were found and briefly described by von Linstow (Lühe, 1909), who gave the name *Distomum pulicis* to the *encysted* larval trematode. Neither the cercaria nor the adult was known.

The thin-walled oval cyst measures 0·27 mm. × 0·19 mm. The stylet which is shed after encystment lies free within the cyst. The encysted distome is spatula shaped and shows considerable development. Measurements of the worm are: length 0·51 mm., breadth 0·152 mm., oral sucker 0·107 mm. diameter, ventral sucker 0·058 mm. Body spines are more pronounced and the intestinal caeca extend almost to the posterior extremity of the body. The oesophagus is extremely short—von Linstow states that it is absent. The excretory system shows an increase in size of the ducts, though the number of flame cells has only increased by two, *i.e.* 30 flame cells altogether. The excretory vesicle has disappeared, the two main canals, together with the canals into which they pass, forming a distinct Y-shaped structure, the excretory pore being terminal. The most marked development is shown in the genital system. A cirrus sac lies just in front of the ventral sucker, the genital pore being median. Behind the ventral sucker, and a little to one side is the ovary, and the testes lie obliquely one behind the other near the posterior end of the body. The immature worm evidently belongs to the family *Plagiorchiidae*, and although the final host is unknown, evidence suggests that it is an aquatic bird.

Cercaria pseudarmata sp.inq.

(Plate II, figs. 19–21.)

This larva resembles *C. armata* von Siebold, the only apparent difference being the relative sizes of the two suckers. This difference is also shown in the subsequent stages of the life history. *C. pseudarmata* develops, as does *C. armata*, in the digestive gland of *Limnaea stagnalis*. It occurs in short S-shaped sporocysts about 0·79 mm. long. The body of the cercaria is 0·337 mm. long and the tail, which is somewhat shorter than the body, is 0·27 mm. long. A well-developed stylet 0·027 mm. long is situated at the anterior end of the body, dorsal to the oral sucker. At the sides of the stylet are the openings of ducts leading from four pairs of stylet gland cells situated at the sides of the ventral sucker. The posterior two-thirds of the body is filled

with cystogenous gland cells. The oral sucker has a diameter of 0·065 mm., whilst the small ventral sucker is 0·052 mm. across. In *C. armata*, the oral sucker is much smaller than the ventral sucker. The short prepharynx is followed by a muscular pharynx, oesophagus, and intestinal caeca extending to the posterior end of the body. The bilaterally symmetrical excretory system comprises anterior and posterior lateral ducts, which unite near the ventral sucker to form the V-shaped main collecting canals, which open after joining an excretory vesicle at the posterior end of the body. A duct from the excretory vesicle runs into the tail. A small, slightly dorsal, excretory pore is situated near the posterior extremity of the vesicle. The anterior lateral duct receives accessory ducts from two groups of 3 flame cells each, one group situated near the oral sucker and the second group in the region of the ventral sucker. The posterior lateral duct receives accessory ducts from 5 flame cells in the posterior region of the body. Near the junction of the two lateral ducts the anterior one is considerably looped, in most cases obscuring the junction. Altogether, there are 22 flame cells, 11 on each side of the body. The genital system consists of masses of small round cells at the side and behind the ventral sucker. The cercaria leaves its first host and encysts under the chitinous exoskeleton of the posterior segments of the larva of *Chironomus plumosus*. There are 5–12 cysts in infected larvae and these are generally in the last three segments of the body. The presence of cysts apparently does not affect the development of the larva, which pupates and emerges as the imago in the normal way. The small spherical thin-walled cysts have a diameter of 0·156 mm. It is very difficult to remove the worm from the cyst, and all the worms, which I was able to remove whole, showed no greater development of the genital system than the cercaria. The measurements of the cyst and the suckers of the worm correspond to those of the encysted stage of the distome *Lecithodendrium ascidia* (v. Ben), parasitic in the intestine of the water bat *Leuconoë Daubentini* (Leisl) and in most other middle European bats. Braun (1879–93, p. 865) gives *C. armata* as the cercaria of *L. ascidia* (v. Ben) with *Ephemera* and *Perla* larvae as the second intermediate hosts, according to von Siebold, and the larva of *Chironomus plumosus*, according to von Linstow. Lühe (1909) on the other hand states that it is doubtful whether *Ephemera* and *Perla* larvae are the intermediate hosts of *C. armata*, and does not mention *Chironomus plumosus*. In his description of *L. ascidia* he makes no reference to *C. armata*. The relative size and position of the suckers of cercariae are usually sound characters in affording clues to the further development, and, if they hold in this case, *C. armata*, in which the ventral sucker is larger than the oral sucker, cannot be the larval form of *L. ascidia*, in which the oral sucker is larger than the ventral one. It is evident that considerable confusion exists in this life history, and also that more work is necessary before it can be completely settled.

Cercaria leptosoma n.sp.

(Plate III, figs. 22, 23.)

C. leptosoma develops in large white sausage-shaped sporocysts about 1·4 mm. long, in the digestive gland of *Limnaea peregra*. The cercaria is 0·32 mm. long and the tail, which is shorter than the body, has a length of 0·257 mm. The body is covered with transverse rows of small spines, and a stylet 0·026 mm. long is situated at the anterior end. The oral sucker is very muscular, 0·076 mm. in diameter, and larger than the ventral sucker, which is 0·065 mm. across. The muscular pharynx is preceded by a short prepharynx and followed by a long oesophagus and intestinal caeca which reach almost to the posterior end of the body. Five pairs of stylet gland cells lie in two groups on each side of the ventral sucker, and from these ducts arise and open on each side of the stylet. The posterior two-thirds of the body is filled with finely granular cystogenous cells. The excretory system consists of anterior and posterior lateral ducts uniting at the sides of the ventral sucker with the main collecting canals which enter a large excretory vesicle. A small excretory pore is present on the dorsal surface of the vesicle near the junction of the body with the tail. The main collecting canals form a Y-shaped structure posterior to the ventral sucker. The anterior lateral duct receives accessory ducts from two groups of three flame cells, one group near the oral sucker and the other lateral to the ventral sucker. Between these two groups are ducts from two independent flame cells. The posterior lateral duct receives accessory ducts from three groups of three flame cells each. In all there are 34 flame cells, 17 on each side of the body and arranged in the following order from the anterior end $(3 + 1 + 1 + 3) + (3 + 3 + 3)$.

Rudiments of the genital system occur in the form of small round cells posterior and slightly to one side of the ventral sucker. The further history of this larva is unknown. As *Gammarus pulex* is the second intermediate host of several stylet cercariae, attempts were made to infect freshwater shrimps with *C. leptosoma*, but although the infection experiments were continued for a fortnight, no infection took place.

V. Fork-Tailed Cercariae.

This group of cercariae possess a long forked tail and develop in elongate slender sporocysts, capable of independent movement. So far as I know, these are the only larval distomes which possess flame cells in the tail.

Cercaria fissicauda (La Val.).

(Plate III, figs. 24–25.)

C. fissicauda develops in extremely long slender sporocysts 3·0 to 4·0 mm. in the liver of *Limnaea stagnalis*. In most cases the organ is a tangled mass of sporocysts with one free end, which is club-shaped, projecting from the

liver tissue, and capable of independent movement. There is no birth-pore; the cercariae escape by the rupture of the sporocyst walls.

The slender, cylindrical, transparent cercaria, which is positively phototropic, is 0·246 mm. long. The stem of the tail, which is almost as long as the body, is 0·234 mm. long, and each fork is 0·246 mm., so that the whole tail is almost twice the length of the body. Surrounding the anterior end of the body are several closely set rows of small spines, which are more sparingly distributed in transverse rows over the body of the cercaria. The protrusible oral sucker is 0·043 mm. in diameter and is equal in size to the ventral sucker, which is situated well behind the middle of the body. The prepharynx is short, oesophagus long, and the intestinal caeca extend nearly to the posterior end of the body. Two pairs of gland cells, the ducts of which open at the extreme anterior tip of the body, are situated just in front of the ventral sucker. The excretory system consists of anterior and posterior lateral ducts, which join the main collecting canals on either side of the ventral sucker. The main collecting canals are also united by means of a transverse canal passing across the body well in front of the ventral sucker. The two main canals approach each other posteriorly, join, and empty into the small excretory vesicle, from which a duct runs into the tail stem. This duct divides near the bifurcation of the tail, each duct passing down the tail forks and opening on their inner margin by a small pore.

The anterior lateral duct receives ducts from three single flame cells, whilst the posterior duct receives accessory ducts from four flame cells in the posterior region of the body, and a duct from two flame cells in the tail. There are thus 18 flame cells, 9 on either side of the body. In a few cercariae there were only 2 flame cells in the tail instead of the usual 4.

Further history unknown.

Cercaria macrosoma n.sp.

(Plate III, figs. 26, 27.)

C. macrosoma develops in elongate, slender, thin-walled sporocysts parasitising the digestive glands of *Limnaea stagnalis*. The free ends of the sporocysts which project from the liver tissue are not club-shaped, but are capable of independent movement. The comparatively large cercaria is positively phototropic and possesses two black eye-spots 0·005 mm. in diameter, on the dorsal surface of the body, midway between the two suckers. Like all fork-tailed cercariae, it swims tail foremost in a jerky manner, by means of S-shaped movements of the tail, occasionally resting in the water, when the tail with its extended forks acts as a float. The complete tail (0·61 mm.) is longer than the body, which is 0·32 mm. in length. The latter is covered with transverse rows of minute spines, which are more closely set in the region of the oral sucker. This is protrusible, 0·029 mm. wide and 0·035 mm. long, whilst the ventral sucker, situated just behind the middle of the body, is slightly smaller, having a diameter of 0·025 mm. The ventral sucker is also

protrusible and is attached to the dorso-lateral region of the body by means of two well-marked muscle bands. Two pairs of large salivary gland cells are situated between the ventral sucker and the posterior end of the body, filling that region completely. The ducts from these, four in number, open in pairs on two papillae at the tip of the oral sucker. The alimentary canal is represented solely by a small muscular pharynx, which is also furnished with lateral muscle bands.

The excretory system comprises anterior and posterior lateral ducts which unite on either side of the ventral sucker to form two main collecting canals, which in turn discharge into the small Y-shaped excretory vesicle at the posterior extremity of the body. Three flame cells in the anterior region of the body enter the antero-lateral duct and four enter the posterior duct: the flame cell from which the posterior duct arises being situated in the tail. Altogether there are 14 flame cells, 7 on each side of the body. A fine duct passes down the tail stem, bifurcating at the fork; each duct passing to the inner lateral margin of each fork respectively. The genital system is still undeveloped.

Further history unknown.

Cercaria micromorpha n.sp.

(Plate III, figs. 28–30.)

C. micromorpha occurs in long slender irregular sporocysts in the digestive gland of *Limnaea peregra*. The sporocysts, which are full of cercariae in all stages, vary considerably in length, the longest being 1·7 mm. The cercaria is very small, 0·192 mm. long, and very transparent. The tail stem, which is slightly shorter than the body (0·168 mm.), is forked at its free end, the forks being 0·192 mm. long, so that the complete tail is almost twice the body length. The tail stem contains six pairs of large well-defined, clear, circular cells, which appear to be attached to the excretory duct of the tail. The body is covered with extremely small, sparingly distributed spines, which however are more closely set in the region of the oral sucker. The latter is protrusible, 0·032 mm. in diameter, and equal in size to the ventral sucker, which is set with small spines on its inner margin. Just behind the oral sucker is a small muscular pharynx, but the oesophagus and intestinal caeca are apparently absent. Two pairs of salivary gland cells, situated posterior to the ventral sucker, lead by means of ill-defined ducts to the anterior edge of the oral sucker, where they open on two small papillae. The bilaterally symmetrical excretory system consists of anterior and posterior lateral ducts, which join after considerable convolutions to form the main collecting canals leading into the small Y-shaped excretory vesicle at the junction of the body and the tail. From this vesicle a duct passes down the tail, bifurcating at the fork, each duct then passing to the inner lateral margins of each fork. The anterior lateral duct receives ducts from only two flame cells, whilst three flame cells, one of which is situated in the tail, run into the posterior lateral duct. The

junction of anterior and posterior lateral ducts is obscured by their many convolutions in the lateral regions of the ventral sucker. There are 10 flame cells in the body, *i.e.* 5 on each side. The genital system is undeveloped.

Further history unknown.

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EXPLANATION OF PLATES I—III.

KEY TO LETTERING OF PLATES.

a.c., alimentary canal; *a.l.d.*, anterior lateral duct; *b.p.*, birth-pore; *c.* cercaria; *c.p.*, caudal pocket; *e.p.*, excretory pore; *e.s.*, eye-spots; *e.v.*, excretory vesicle; *f.c.*, flame cell; *g.p.*, genital pore; *g.s.*, genital system; *i.*, intestine; *l.d.*, lateral duct; *m.c.c.*, main collecting canal; *o.*, ovary; *o.s.*, oral sucker; *ph.*, pharynx; *p.ph.*, prepharynx; *p.l.d.*, posterior lateral duct; *s.g.*, salivary glands; *st.*, stylet; *st.g.*, stylet glands; *t.*, testes; *t.d.*, transverse duct; *v.d.*, vas deferens; *v.s.*, ventral sucker; *v.*, vitellaria.

Note. Measurements refer to body of Cercariae only.

PLATE I.

Figs. 1–6. *C. echinata* von. Sieb.

Fig. 1. Cercaria, anatomy (length 0·64 mm.).
Fig. 2. Cercaria, excretory system.
Fig. 3. Redia (length 3·5 mm.).
Fig. 4. Cyst (diameter 0·24 mm.).
Fig. 5. Immature trematode from cyst (length 0·68 mm.).
Fig. 6. Immature trematode from intestine of young mallard (length 0·71 mm.).
(The excretory system has been omitted for clearness.)

Figs. 7–10. *C. granulosa* n.sp.

Fig. 7. Redia (length 2·92 mm.).
Fig. 8. Young redia (length 0·5 mm.).
Fig. 9. Cercaria (length 0·37 mm.).
Fig. 10. Cyst (diameter 0·17 mm.).

PLATE II.

Figs. 11–13. *C. equispinosa* n.sp.

Fig. 11. Redia (length 3·04 mm.).
Fig. 12. Cercaria (length 0·293 mm.).
Fig. 13. Cyst (diameter 0·157 mm.).

Figs. 14–18. *C. pulicis* n.sp.

Fig. 14. Sporocyst (length 0·87 mm.).
Fig. 15. Cercaria, anatomy (length 0·31 mm.).
Fig. 16. Cercaria, excretory system.
Fig. 17. Cyst (0·27 mm. × 0·19 mm.).
Fig. 18. Immature trematode from cyst (length 0·51 mm.).

Figs. 19–21. *C. pseudarmata* sp.inq.

Fig. 19. Cercaria, anatomy (length 0·33 mm.).
Fig. 20. Cercaria, excretory system.
Fig. 21. Cyst (diameter 0·156 mm.).

PLATE III.

Figs. 22, 23. *C. leptosoma* n.sp.

Fig. 22. Cercaria, anatomy (length 0·32 mm.).
Fig. 23. Cercaria, excretory system.

Figs. 24, 25. *C. fissicauda* (La Val).

Fig. 24. Cercaria, anatomy (length 0·25 mm.).
Fig. 25. Cercaria, excretory system.

Figs. 26, 27. *C. macrosoma* n.sp.

Fig. 26. Cercaria, anatomy (length 0·32 mm.).
Fig. 27. Cercaria, excretory system (side view).

Figs. 28–30. *C. micromorpha* n.sp.

Fig. 28. Part of sporocyst.
Fig. 29. Cercaria, anatomy (length 0·192 mm.).
Fig. 30. Cercaria, excretory system.

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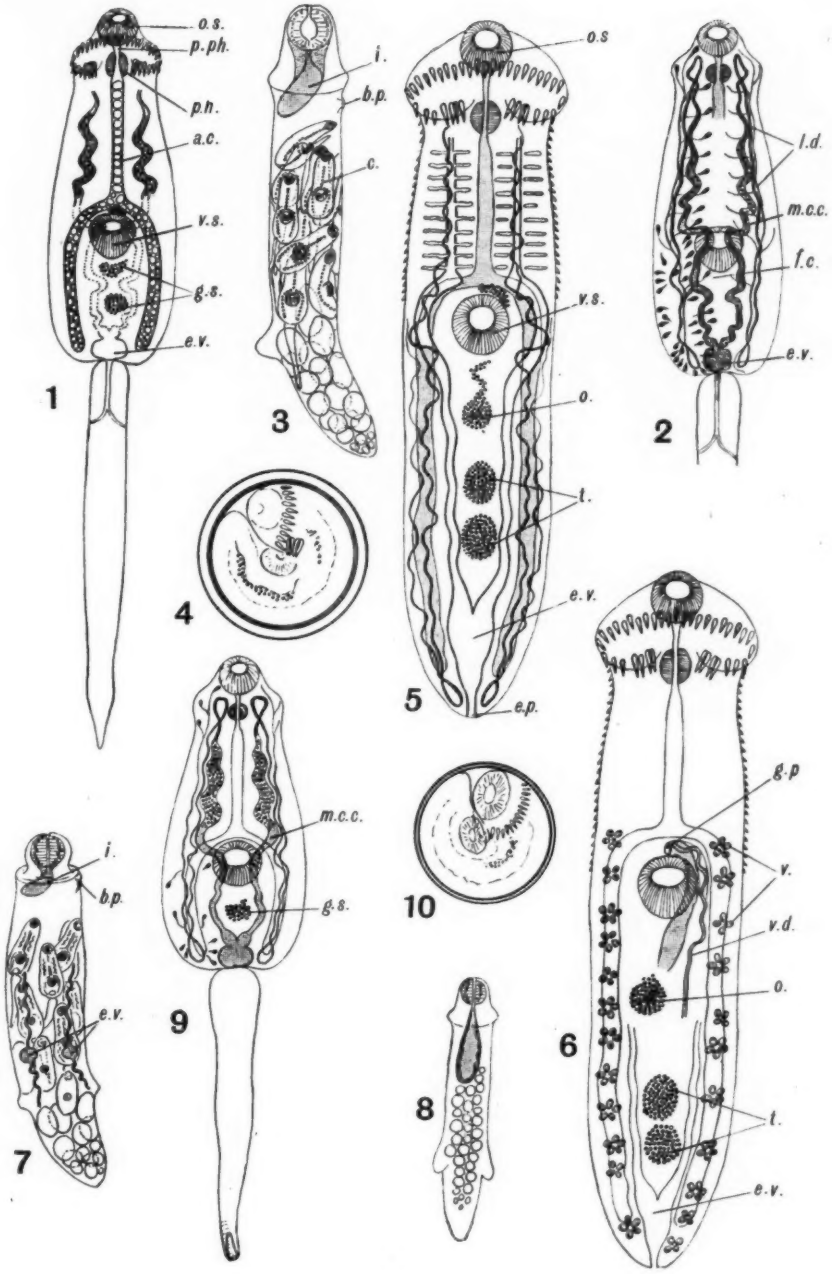
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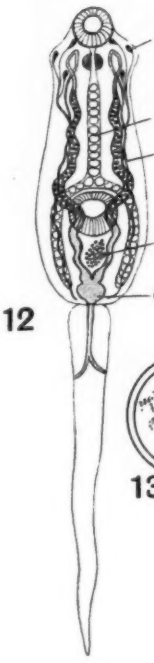

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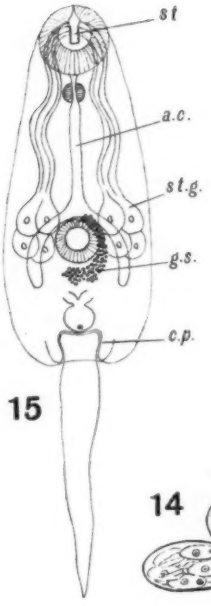

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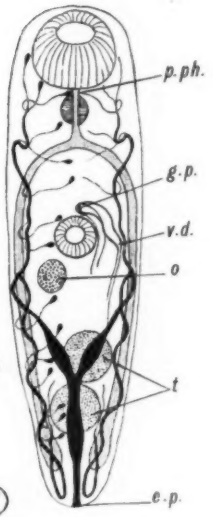

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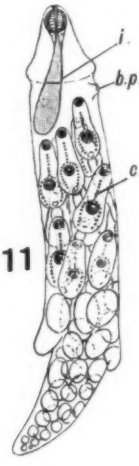

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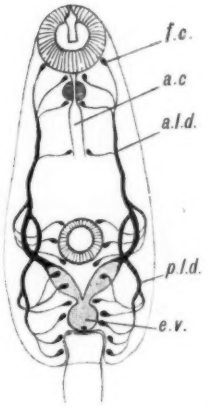

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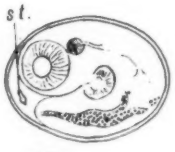

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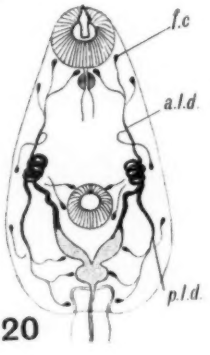

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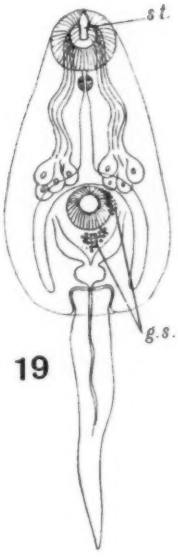

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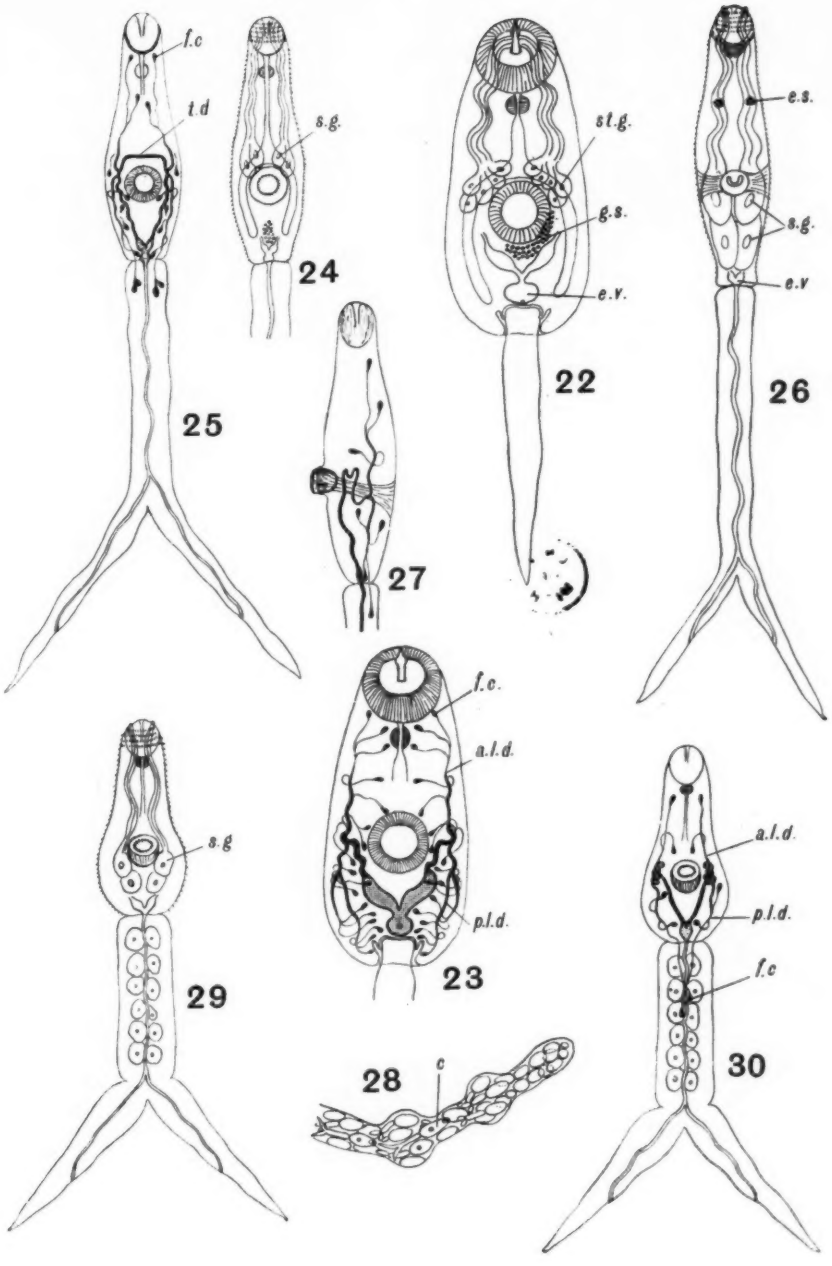
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STUDIES ON *HIPPOBOSCA MACULATA* LEACH AND *H. EQUINA* L. IN THE DUTCH EAST INDIAN ARCHIPELAGO.

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(With Plate IV, 1 Map and 5 Text-figures.)

CONTENTS.

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Introduction.

Our knowledge regarding the biology of Hippoboscidae is but fragmentary. Leuckart (1858) and Pratt (1900) have described the embryology of *Melophagus ovinus* L. Austen (1903), who described the puparium of *Hippobosca maculata* Leach, found that the females soon starve when removed from their host. Austen continues: "It is believed that the females of the genus *Hippobosca* deposit their larvae on the ground, but it is not definitely known, whether they bury them or merely place them on the surface. Several pupae of *H. maculata* have been found in the calf sheds of the King Institute, but it is not clear, as to whether they were intentionally or accidentally deposited there." Theobald (1908), on the contrary, asserts that female *H. camelina* and *H. maculata* attach their pupae to their host's hair. Massonat (1909) relates that the pupation period of *H. equina* varies with the temperature. Most imagines emerge after 30 days, a few after 35 days, and in some cases pupae, opened by the author 50 days after deposition, contained living flies.

It appears to me questionable, whether these flies were still able to break their own shell or not.

It is evident from the foregoing, that hitherto little has been known of the life-cycle of Hippoboscids. Happily I have had good opportunities afforded me for studying the biology of *H. maculata* under natural conditions at Soemba and in the fly-proof stables at the Veterinary Laboratories, Buitenzorg.

I. **Hippobosca maculata** Leach.

1. *Geographical distribution in the Timor Archipelago.*

(See Map, facing this page.)

H. maculata abounds upon the islands of the Timor Archipelago: Soemba, Savoe, Rotti and Timor, where it is a serious pest to horses. The results of my researches are as follows:

Java. H. maculata is met with occasionally. Specimens came into our possession, taken from imported horses, at Batavia, Semarang, Tegal and Soerabaia, and from horses in the neighbourhood of Soerabaia. I collected specimens from horses in the neighbourhood of Batavia and on pasture land at Buitenzorg about our laboratory in 1921, but they have disappeared since then from these places for no apparent reason. It is curious that the fly does not establish itself in Java.

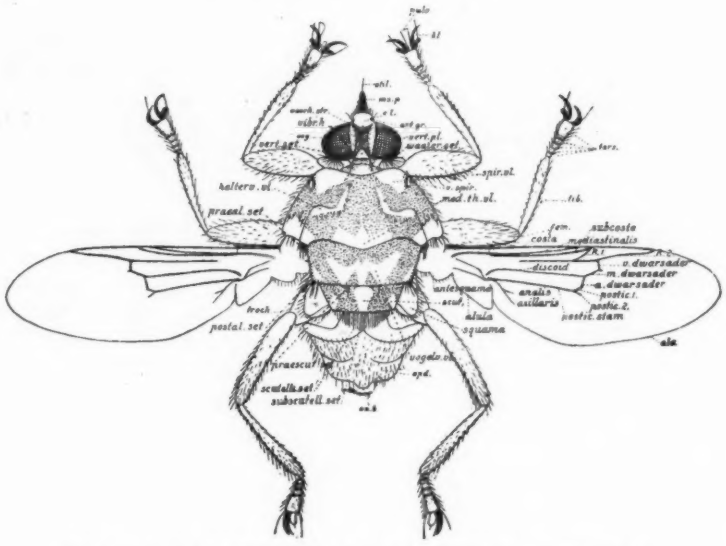
Soemba. Visiting this island, I journeyed from Waingapoe as a centre to different parts, finding everywhere *H. maculata* only. Some local cattle- and horse-breeders informed me that this fly first appeared on the island with imported Bengalese cattle in 1915, but others assert that the fly was well known there long before. A civil officer, residing for many years at Soemba, told me that he never saw the flies before the importation of Bengalese cattle. According to Aljouffrie, an Arab horse-breeder, the numbers of this fly have diminished of recent years; he for the preceding four years had periodically collected his horses in special compounds to rid them of the flies, and appears to have partly succeeded.

Savoe. I found only *H. maculata* on this island, though according to Wiradinata, the Assistant Veterinarian, *H. equina* must have formerly prevailed there. In 1921 a great mortality occurred among horses and *H. maculata* abounded. In 1922 the fly had decreased in number. It may have been introduced from Timor (*vide infra*).

Rotti. Here *H. maculata* abounded in 1922. As at Savoe *H. maculata* may have been introduced with horses from Timor (*vide infra*). I sought in vain for *Melophagus ovinus* on sheep.

Timor. I found *H. maculata* on horses at Timor Koepang, Babaoe, Noël Mina (600 m. elevation). According to Wiradinata the fly probably reached the island in 1917 with Ongole bulls, imported from Soemba. In 1918 Australian cattle brought from Soemba were certainly infested with the fly. In 1919–20 the Veterinary Reports record a greatly increased fly prevalence and considerable mortality in foals; this mortality decreased in 1921. The fly had

evidently spread over the whole island; it is reported from Beloe in the northern part of Dutch Timor and probably will be also found in the Portuguese part of the island. Horses conveyed to Java by vessels touching at Rotti and Savoe have doubtless served to disseminate the fly upon these islands.



Text-fig. I. *Hippobosca maculata* Leach. Schematic figure (Siswo del.).

stil. = stilet.
mx. p. = maxillary palps.
cl. = clypeus.
vibr. h. = vibrissal hairs.
ant. gr. = antennal groove.
vert. pl. = vertex plate.
waaier. set. = fan-like group of setae.
halterv. vl. = halter-shaped spot.
v. spir. = first spiracle.
med. th. vl. = middle thoracic spot.
vogelv. vl. = bird-shaped spot.
praeal. set. = prealar setae.
praescut. set. = prescutellar setae.
postal. set. = postalar setae.
scutell. set. = scutellar setae.
subscutell. set. = subscutellar setae.
an. h. = anal protuberance.
scut. = scutellum.
troch. = trochanter.
kl. = claw.
pulv. = pulvillus.
tib. = tibia.
fem. = femur.
R. 1 = Radial 1.
R. 2 = Radial 2.
v. dwarsader = anterior cross-vein.
a. dwarsader = posterior cross-vein.
m. dwarsader = middle cross-vein.
postic. 1 = postical 1 or upper branch of post.
postic. 2 = lower branch of postical.
postic. stam. = trunk of postical.

Flores. H. maculata was found at Endeh by me. Occasionally cattle for slaughter are imported from Soemba; in 1920–1 the transports conveyed the fly and in 1921 they swarmed at Manggaray, Reo and Laboean Badjo, many casualties being reported among horses along the coast. The veterinarian Doeve states that Hippoboscids were brought to Laboean Badjo with stallions

from Soemba, where they were stationed for breeding purposes. This version is probably correct, but it must always be remembered that horses fret visibly when first attacked by Hippoboscids, so that these can scarcely be overlooked, whereas the contrary prevails, when horses become more or less accustomed or indifferent to their presence.

H. maculata occurred on imported horses at Makassar.

2. *Morphology.*

Much work has been done on the morphology of Hippoboscids (see the papers by Leuckart, Pratt, Speiser, Ferris and others). I will refer here only to the most important characters of this insect. The pregnant female (Pl. IV, fig. 2 and Text-fig. II, 2) with her dilated abdomen is easily distinguished from the male (Pl. IV, fig. 1 and Text-fig. II, 5, 6, 7), whose penis may be protruded by pressing gently on the abdomen. The circular outline of the female abdomen is only broken by the anal protuberance consisting of two chitinised lobes and bearing ventrally the anal opening. The latter is bordered at its base by a horse-shoe-like chitinised rim (Text-fig. II, 5). A second chitinous piece placed at right angles to the first separates the anus from the vagina (Text-fig. II, 5 and Text-fig. III, 8). Adanal and praeanal plates, covered with black bristles, encircle the anal protuberance. The penis (Text-fig. II, 6–8 and Text-fig. IV) is whitish and bladder-shaped, with a finger-like projection supported by three chitinous rods resting on the penis collar. When the penis protrudes the lateral rods spread. The adanal plates in the male are round, very small, and sometimes hidden under the big praeanal plates.

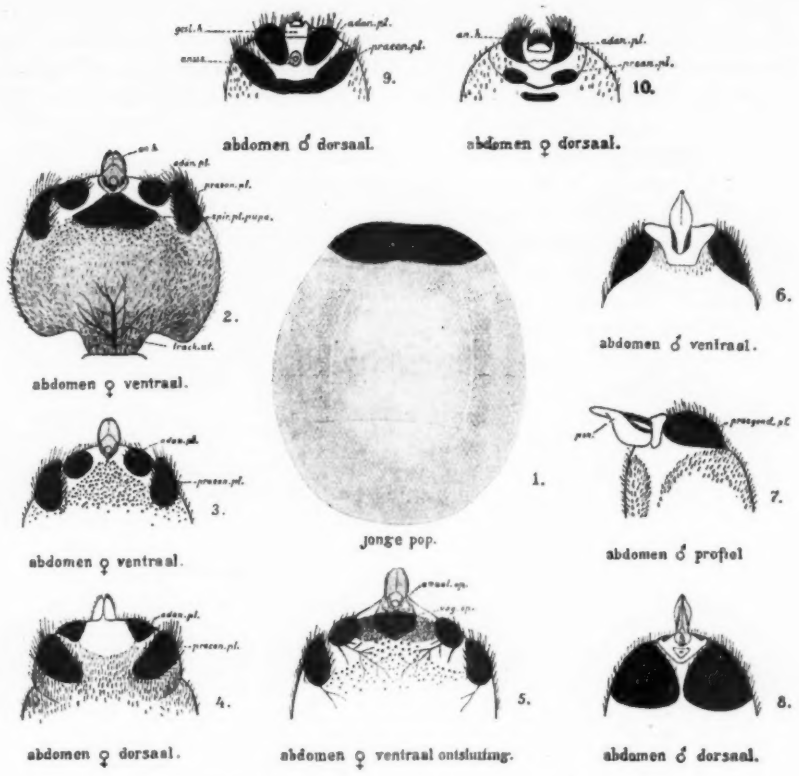
Cole and Ferris have discussed the systematic value of chaetotaxy in Hippoboscids. For the head and its appendices compare Mueggenburg's paper on *Melophagus ovinus*. The frontal vitta shows 2 rows of 7 (3 long and 4 short) hairs. The back of the head bears 2 fan-like groups each composed of 10 yellowish-white bristles. The plate distinctly shows the distribution of the ivory-yellow spots (*i.e.* the spiracular spots (*spir. vl.*), the halter-shaped spots (*halterv. vl.*), the median thoracic spot (*med. th. vl.*), the bird-shaped spot (*vogelv. vl.*), etc. The pubescence on the scutum and the scutellum is scarce. Hairs and hair-groups are distributed on the left half of the body as follows:

6 praealar hairs (*praeal. set.*); 8 postalar setae; 1 prescutellar hair; 7 scutellar hairs in ♀, 12 in ♂; a row of subscutellar hairs; 6 or 7 hairs, situated behind and median to the halter-shaped spot; 5–7 short hairs in front of and laterally from the median praealar spot; the lateral border of the scutum is fringed with hairs of medium size; borders of sternites thickly fringed.

Squama and antesquama of wing fringed with short white pubescence. Femora thickly beset with long hairs, tibiae with scanty pubescence, scattered over the surface.

3. *Pupa.*

When brought into captivity the female deposits its white larvae (Text-fig. II, 1) bearing a black postabdominal spiracular plate, covered with black



Text-fig. II; 1 to 8 refers to *H. maculata*, 9 and 10 to *H. equina*.

1 Young pupa of *H. maculata*.

2 Abdomen of high-pregnant female: *an. h.* = anal hill; *adan. pl.* = adanal plate; *praean. pl.* = praeanal plate; *spir. pl. pupa* = spiracular plate of pupa; *trach. ut.* = tracheae uteri.

3 = female, abdomen, ventral view.

4 = female, abdomen, dorsal view.

5 = female, abdomen, ventral view, disclosing vagina in the process of extrusion of a larva: *vag. op.* = vaginal opening.

6 = male, abdomen, ventral view.

7 = male, abdomen, side view: *praegenit. pl.* = praegenital plate; *pen.* = *penis*.

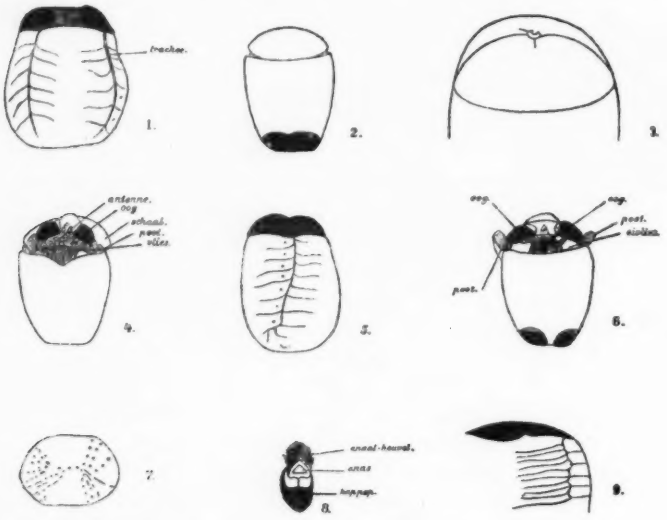
8 = male, abdomen, dorsal view.

9 = *H. equina*, male, abdomen, dorsal view: *gesl. h.* = sexual promontory; *adan. pl.* = adanal plate; *praean. pl.* = praeanal plate.

10 = female abdomen of the same: *an. h.* = anal hill.

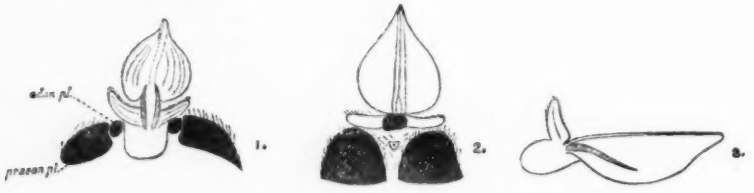
warts. A few hours later the colour changes from white to yellowish-brown and finally to shining black. Now the larva has pupated. The structure of the spiracular plate is similar to that of *Ornithomyia strigilecula* as described by Ferris. It is hexagonal and is subdivided into two fields. The 3 spiracular tracheae of each field unite with the corresponding longitudinal tracheal

trunk. The latter gives rise to 6 pairs of branches. A series of dents upon the skin which are visible between the tracheal branches correspond according to Pratt to the places of insertion of muscular bands. The spiracular plate bears also the anus of the larva. The anterior end of the body shows a small



Text-fig. III. *H. maculata* (J.H.S.S. Jr. del.).

1 Young pupa, dorsal view.
2 Pupa opened.
3 Upper part of the larva.
4 An imago emerging, ventral view.
5 Pupa, lateral view.
6 Emerging imago, dorsal view.
7 Spiracular plate, seen from above.
8 Genitalia, *anas* = anal fissure.
9 Pupa, ventral view.



Text-fig. IV. *H. maculata*, male genitalia.

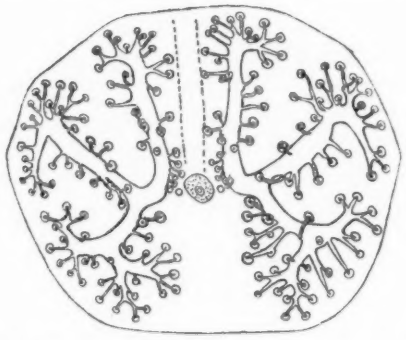
1 Dorsal view. 2 Ventral view. 3 Side view.

retractile process bearing a protruded hair. The larva shows already the grooves which correspond to the line of splitting of the puparium during the emergence of the adult fly. In my experiments the pupae were always found upon the surface of the sand covering the floor of the breeding cage, and in no case was a pupa observed to have been buried in the ground.

4. *Pupation period.*

Most of my experiments upon the pupa of *H. maculata* were conducted at the Government Horse Depot, Waingapoe, and in fly-proof stables at Buitenzorg. To determine the duration of the pupal stage I collected: (*a*) pupae, at the most a few hours old, from breeding-places; (*b*) females, and confined them in breeding cages where they were observed to lay larvae.

It is inexpedient to tamper with the larvae, the skin of which is very soft and easily injured. Before being handled they must be given time to pupate, *i.e.* to acquire a hard chitinous envelope. Otherwise the pupae fail to yield the imagines. No adults emerged from 60 pupae that were prematurely handled. Of 61 pupae allowed to harden before being touched, 39 (23 ♂ and 16 ♀) imagines were obtained. The pupal stage lasted in this case from 24–



Text-fig. V. *H. maculata*, spiracular plate of unripe larva.

28 days: [24 days (1 ♀), 25 days (4 ♂, 2 ♀), 26 days (9 ♂, 5 ♀), 27 days (6 ♂ 6 ♀), 28 days (4 ♂, 2 ♀)]. Similar observations on young pupae, collected at Soemba and elsewhere, yielded the following figures:

Pupal stage lasted	22	23	24	25	26	27	28	29	days
in	1	3	29	35	47	24	11	1	cases
	1 ♂	2 ♂, 1 ♀	19 ♂, 10 ♀	18 ♂, 17 ♀	29 ♂, 17 ♀	14 ♂, 10 ♀	6 ♂, 5 ♀	1 ♂	

Therefore the pupal stage lasted from 22 to 29 days, the average being 25·5 days. The sexes developed at an equal rate. Sex ratio 2 ♂ : 3 ♀.

Experiments in a fly-proof stable at Buitenzorg gave the following results (sexes not noted):

Pupal stage lasted	18	19	20	21	22	23	24	25	26	27	28	days
in	4	2	3	3	5	5	28	44	26	14	6	cases

Therefore the pupal stage lasted from 18 to 28 days, the average being 24·7 days. Allowing for possible sources of error, the minimum duration of the pupal stage observed at Buitenzorg was distinctly shorter than at Soemba. We have evidence, that pupae derived from primiparous females develop

somewhat sooner than the multipara derived, this depending upon better nutrition of the former.

Impeded pupal development. Two of our records show that (*a*) 72 out of 150, and (*b*) 883 out of 1765 pupae failed to yield imagines. Of 40 examined out of lot (*a*) 30 had not undergone development and 10 were found to contain full grown imagines, whilst of 62 examined out of lot (*b*) 28 proved to be undeveloped and 8 contained imagines. Two apparently living imagines were found in their pupal cases after 49 days. It is probable that after the lapse of 29 days the imago is too feeble to emerge. The injury inflicted by enemies of *H. maculata* (apart from the imperfect conditions for development of the pupae, transportation, etc.) accounted for a part of the greater loss of life we observed in Soemba as compared with Buitenzorg.

5. *Sex Ratio.*

Out of a total of 1562 *H. maculata* comprised in 5 different catches, 804 were ♂ (51·4 per cent.) and 658 were ♀ (48·6 per cent.). The proportion of the sexes when analysed for the 5 arbitrary catches above mentioned, afforded the widely divergent results that follow:

Catch		1	2	3	4	5	Totals
Sexes	♂	194	68	64	404	104	804
	♀	158	90	76	373	61	658

Out of 968 imagines bred at Soemba, whose sexes were determined, 473 were ♂ (48·8 per cent.) and 495 were ♀ (51·2 per cent.). We may conclude therefore that the sexes are produced in about equal numbers.

6. *Time of day when females deposit larvae.*

According to observations communicated to me by Mr Reinecke, he had observed that pupae are mostly dropped about midday. In my breeding-cage experiments, starting at 7 a.m., pupae were mostly deposited between 10 a.m. and noon. I sought to arrive at a conclusion in the matter by a method that consisted in capturing the flies at different times during the day and placing them in breeding-cages in which they were exposed to the vapour of chloroform, to which they are comparatively resistant. As soon as the flies were quiet, I separated them into 4 groups, according to their degree of abdominal distention. The method was a rough one but it gave results proving that the number of females in an advanced state of pregnancy increases towards midday and decreases afterwards, this being indirect but sufficient proof that most pupae are deposited at noon and shortly after. The following record relates to 5 catches, made at stated times during three successive days (4–5–6. VI. 1922). Each catch consisted of 100 flies except in the observation at 5 p.m. on the 2nd day, where but 64 flies composed the catch; in this case only do the figures represent percentages in place of actual counts. The females are grouped according to the degree of distention, the most distended being comprised in Group 4, the least distended in Group 1:

Table showing the period of the day when highly pregnant H. maculata *occur most frequently.*

	Day 1	Day 2		Day 3	
Flies caught at	9 a.m.	9 a.m.	5 p.m.	11 a.m.	5 p.m.
Group 4	29	22	11	46	15
3	34	34	53	35	44
2	23	33	32	19	35
1	14	11	4	—	6
No. of pupae dropped	—	—	14	8	6

Carefully timed observations made in fly-proof stables at Buitenzorg on 30 days between 4. IX. and 13. X. 1922 gave concordant results as follows:

Time of day									
Before						After			
7–8	8–9	9–10	10–11	11–12	12	12–1	1–5	5	12
1	0	1	8	3	17	25	57	39	121

Total number of larvae dropped for each day period in 30 days.

Therefore most larvae are deposited between 12 m. and 5 p.m. but a considerable number are deposited after 5 p.m.

Several times I had the opportunity of observing the emerging of the imago. It takes place in a manner similar to that already described for many other cyclorrhaphous diptera.

7. *Offspring produced by a single female, copulation, rate of development, longevity.*

Offspring: According to Massonat, judging from the appearance of the ovaries, a female *H. camelina* should give birth to 8 pupae. I reached the same conclusion from the examination of *H. maculata*, hatched during my breeding experiments and placed upon a horse, the females being dissected by me at varying intervals. As one or more of the ovules appeared at times to be degenerated, I doubt whether really all eggs give rise to larvae. The number of ova produced by a female varies between 6 and 10.

To determine the number of pupae produced by a single female *H. maculata*, I placed 66 ♂ and 44 ♀ upon a horse in a fly-proof stable on 22. VIII. 1922. Two ♀ died on 8 and 11. IX. 1922 respectively. The first pupae were found on 4. IX. and the last on 24. X. 1922, a total of 192 pupae being produced during this period of seven weeks, this being equivalent to 4·8 pupae per female. The number produced by individual females appears to range between 4 and 6. The second larva is deposited soon after the first, the third and fourth larvae appearing after a longer period owing to the time required for the development of the ova within the female. The females were repeatedly seen to fly away from the host and deposit their larvae in slits in bamboo or a hole behind a post in the stable.

Copulation was renewed after larvae were deposited, and mating was witnessed oftenest on days when most larvae were deposited. Isolated pairs were seen to mate twice in a morning. The process usually lasted some minutes; in one case it lasted 47 minutes. The male rests upon the back of the female and embraces her neck with his forelegs. The female spreads her wings widely and the male bends his abdomen, making rhythmical movements while *in copula*. Apart from this I observed what Wilhemi terms "spielflug" copulation.

Rate of development: My experiments show that pupae first appear 12–14 days after copulation has occurred and that the pupal stage lasts on an average 25 days, the life-cycle being completed in about 38 days.

Longevity: Imagines maintained with horses in fly-proof stables lived at longest about 4 months. When kept unfed and apart from the host all the flies died within 3 days (674 imagines tested), at times they died within 24–48 hours. The males die more rapidly than the females, the latter having more reserves to draw upon.

8. *Breeding places.*

Although it has been stated that pupae of *Hippobosca* occur in cow dung, more especially in buffalo droppings, and at times in horse dung, I have failed to confirm the statement.

The only trustworthy observation hitherto recorded is that of Austen, who found *H. maculata* pupae in calf-sheds at the King Institute in India. Austen, moreover, writes: "it is believed that female *Hippobosca* deposit their larvae on the ground."

Most of my observations were made at Soemba, whilst a few were made at Savoe and Rotti Islands (see Map, facing p. 36), and they may be summarised as follows:

(1) *Pupae found in fodder-troughs and woodwork of horse-sheds.* At Waingapoe, Soemba, the Government Horse Depot, I usually found pupae in the morning on searching in the fodder-troughs in the large open shed where the horses were regularly assembled between 7 and 11 a.m. Pupae were also found in the joints of the beams and posts supporting the sheds. Nine-tenths of the pupae were found on the side exposed to the morning sun. I several times saw imagines leave horses and alight in the fodder-troughs where pupae were subsequently found. Obviously these troughs afford an excellent habitat for the pupae. Only once did I find a pupa in the ground beneath a trough. As the horses resorted to the shed for only about 4 hours in the day a larger number of pupae will necessarily have been distributed upon the surrounding pastureland and this accounts for the relatively small number (90 in 20 days) collected by me in the shed.

(2) *Pupae found in cracks in bark, in holes and about roots of trees, in cracks in woodwork fences and gates, between stones, etc.* I have found pupae in coconut trees whose stems are often notched by the natives to facilitate climbing. The pupae were found in cracks in the bark or in the leaf-sheath of young trees. In Waingapoe, mango trees, interspersed with cocos, afford

shade which is sought by stock animals. At Maoe Djawa, Soemba, I found pupae in holes in the bark of trees at a height of 6 metres above the ground. Pupae also occurred in holes in mango trees. Two holes in one tree harboured no less than 19 and 23 pupae or pupa-cases respectively.

At Maoe Djawa pupae were found in holes and interstices in a wooden fence and gate of an enclosure used for cattle. Pupae were also found in holes, in cracks in bark, and topped branches of trees. Two trees yielded 138 pupae (74 intact). Trees near a water-trough usually harbour more pupae and once I found 168 pupae in a post near such a trough. Failing wood, the pupae may be found between stones about compounds. At Watoe Mbaka, where horses grazed along the sea shore on grassy plains, pupae were found in the holes and cracks in the bark of shade trees (Ficus, tamarinds, bushes) and between the roots of tamarinds. The sheaths of lontar palm-leaves left after the leaves have fallen, often harbour pupae.

(3) *Pupae occur on pasture grounds:* It is clear that given the limited progeny of the insect and the difficulty of finding so inconspicuous an object as its pupa upon grass covered ground, to search for the pupae on the ground would be hopeless. On several occasions I picketed a horse in the open and observed the behaviour of the flies closely in the hope of solving the problem but failed to do so, never finding pupae upon the ground where the horse had stood or rolled in his efforts to rid himself of the flies. Incidentally, however, I made an observation which supported the view that larvae are deposited in the ground.

Having noticed, as I walked through grass, that *Hippobosca* often settled on my white clothes when cattle were not to be seen in the neighbourhood, I sought to discover if they were derived from pupae which were harboured on the land by using mosquito-net tents for catching the flies on the principle employed by Van Breemen in studying mosquitoes derived from fish ponds at Batavia. Each of my tents covered one square metre of ground and they were placed in various positions. In one out of 8 tents after a period of 3 weeks bodies of two starved *Hippobosca* imagines were found. The experiment should be repeated.

9. *Hosts.*

H. maculata occurs on *horses* far more frequently than on any other animals. A horse may harbour several hundred flies as shown by the following figures, obtained by collecting the flies after dipping a number of horses on different occasions:

Observation	Date (1923)	Number of horses dipped	Total number of flies captured	Average number of flies per horse
1	June 12	38	13,619	358
2	July 3	9	3,658	406
3	„ 3	4	4,358	1089
4	„ 3	17	7,856	462
5	„ 6	27	16,225	600
6	„ 6	40	10,625	265
7	„ 9	39	14,955	383
8	„ 9	37	7,160	193

The horses on the islands I visited were mostly heavily infested. The insects occurred chiefly on the groins, part of the breast and belly, the neck and about the anus. When attacked for the first time by the flies the horse is greatly irritated, but the horse soon grows accustomed to the parasite. Heavily infested horses frequently roll in the grass to free themselves from flies. The natives ascribe the mortality of the horses in the dry monsoon to the influence of the tick-fly and the following experiment tends to confirm this belief:

On 8. IX. 1922 106 tick-flies were placed on a horse, weight 118 kilos. In the beginning of October the horse was found lying prone in the stable. On 7. XI. 1922 the horse appeared entirely exhausted and its weight had fallen to 100·5 kilos. The temperature registered 35·9° C., whilst the mucous membrane of the eyes appeared pale and the red corpuscles numbered 6,000,000 per c.mm. and the leucocytes count being as follows:

Lymphocytes	241	96 %
Neutrophyles	9	4 %
Eosinophyles	—	—
Basophyles	—	—
Transition cells	1	0·5 %

At the autopsy, performed by Dr Du Moulin, a clear serous fluid was found in the pericardium, pleural and abdominal cavities; the heart was dilated, the fat about the heart and kidneys appeared dropsical and the intestinal glands swollen. In the intestine many *Spiroptera* and *Oxyurus* were present. The spleen was atrophic. Leucopenia severe.

H. maculata occurs on *Bengalese cattle*, but only in small numbers (the average number per head, found after dipping 30 cattle, being 40 flies). The insects also occur on *buffaloes*, upon which they settle mainly on the neck and under the breast, but only in moderate numbers. *Goats and sheep* serve as hosts in Savoe and Rotti. In Termanoe on Rotti most of these animals harboured 60 flies or more apiece. *Dogs* are seldom attacked. *Man* is bitten exceptionally, for example, when fording a river with swimming horses; under such conditions *H. maculata* may settle on the neck, face and hands of the rider and suck blood; the bite produces no other effects than a little pain and transitory itching.

10. *Enemies.*

On my trips I occasionally found pupae with pierced shells, most of which were empty. In one case the pupa-case contained a dead imago partly devoured, apparently by small mites, which may or may not have killed the imago; the mites certainly demolished the pupa-case. Mr Lang informs me that he once saw a spider devouring a pupa, but the pupa may have been previously injured. Ants prefer to eat empty pupa-cases; at Soemba I never saw them attack a sound pupa, but at Buitenzorg I found ants attacking young and old pupae.

The imagines being highly chitinised are thereby subject to few enemies. Lizards only eat them when nearly starving. A great enemy is the spider: at Soemba and at Buitenzorg I saw spiders engaged on their nets in catching *H. maculata* and making small balls of them by enclosing them in a web; at

Buitenzorg the flies were partly devoured. These balls were collected in a certain part of the web in a sort of nest and subsequently, when the mother spider had been dead some time, I found many young spiders on the same spot.

The natives told me that white fowls (*Bubulculus coromandus*, common in Soemba) destroy tick-flies in great numbers. These fowls accompany the herds of cattle and horses, settle upon the backs of the animals and eat the insects. As the stomach of such fowls, captured on Java, contained almost exclusively Tabanids, it is very probable that the birds also devour the tick-fly, since Tabanids are rare at Soemba. Having heard that a species of digging wasp is a great enemy of *Hippobosca*, I sought repeatedly to procure some, but I was unsuccessful; I have since heard through Dr Bubberman that Dr Proppe, who visited Soemba after my departure, had found them and observed the capture of the fly by the wasp.

11. *Control measures.*

It is evident that attempts to collect pupae of *H. maculata* (as a control measure) are doomed to failure, though naturally the destruction of pupae when found is always advisable. Although the pupae occur in sheds and enclosures they are mainly scattered about over a considerable area in various hiding places which in practice are inaccessible.

Mechanical removal of the flies: Aljouffrie, an Arab horse-breeder on Soemba Island has for four years past employed a primitive but efficient method of control as follows: The horses are collected once a fortnight and herded in an enclosure (A) whence a gate opens into a second enclosure (B). One horse at a time is driven into enclosure (B) where it is lassoed round the neck, the end of the lasso being tossed over the fork of a tree and caught by a second man who draws it tight, thus forcing the horse to stretch its neck upwards whilst moderately strangling the animal. A third man throws a second lasso around the horse's forelegs and brings the animal to its knees. The first lasso is now somewhat eased, to lessen the stranglehold, and a man by means of a horse-hair whip dislodges the flies from their positions on the horse. The flies, driven away from the lassoed horse, fly to a second tame horse which a man leads round the lassoed one and, when all the flies have disappeared from the latter, the animal is liberated into an adjoining enclosure (C). In the meantime an assistant catches all the flies on the tame horse in enclosure (B) and throws them into a tin of boiling water. The operation is repeated until all the horses have been freed of the insects. Ajouffries states that he can treat 60 horses per hour in this way, and that he has greatly reduced the number of flies on his horses by this routine treatment over a period of four years. This method is employed in other places on the island.

Insecticides tested: I tested various fluid insecticides in the laboratory by immersing numerous imagines of *H. maculata* therein for stated periods. The insects were afterwards transferred to dry containers, where they were subsequently observed to make sure that the insects were killed and not merely

stupefied. My experiments were made with petrol, diesel oil, crude petroleum emulsion, petroleum-soap-water emulsion, petroleum-residuum emulsion, various soap-solutions, carbolineum plantarum and isal emulsions of various concentrations. Excluding the more expensive fluids, the best results were obtained with petroleum and diesel oil which immobilised the flies after an immersion of less than 6 and 13 seconds respectively and killed them.

Sea bathing: The horses at our Government Depot are bathed regularly in the sea and in consequence remain almost free from flies for 2–3 days. At Savoe the horses are bathed in the sea daily. Clean horses have little attraction for *H. maculata*, but flies are soon attracted by the smell of horse sweat, and, settling down on the host, proceed to suck blood. Usually the horses with the dirtiest coats attract most of the flies and these soil the coat still more by voiding their excreta thereon and causing blood to flow from their bites[1].

Dipping: Field experiments were conducted with *H. maculata*-infested horses, the procedure being similar to that usually employed for ridding cattle from ticks. The infested horses were herded in a compound whence a narrow passage led to a dipping vat 16 metres long by 3 metres deep, along which the horses travelled, issuing by steps at the other end into a second enclosure. As it was thought that the insects might take flight from the horses when these became immersed, the vat was covered by netting to serve as a fly-trap, but this precaution proved superfluous for the flies on contact with the dip remained clinging to the horses. The immersion fluid consisted either of (*a*) water covered by a layer of about 3 mm. of petroleum, or of (*b*) $\frac{3}{4}$ per cent. Cossage's soap-solution. The horses passed through the dip in about 15 seconds. In each case the number of flies found in the dipping fluid, in the dropping enclosure, and remaining attached to the horses was recorded. All the horses were passed twice through the dipping process. The number of flies collected from the horses is stated in the table on p. 45. Observations 1–6 were made on animals exposed to dip (*a*) and 7–8 on those immersed in dip (*b*). Moderate numbers of flies dropped off in the vat or dropping enclosure, 7·6 to 29·4 per cent. (minimum and maximum), whilst 53–79 per cent. remained fixed, although lifeless, to the horses. I would recommend two consecutive dippings being employed, although more costly and notwithstanding that few flies survive a single dipping. Cattle may be dipped in similar fashion. It is not necessary to rid the animals of the flies that remain attached after the dipping because they die and drop off. Judging from what we know of the biology of *H. maculata*, dipping should be repeated every two weeks until the amount of infestation is suitably reduced. The establishment of dipping stations in suitable localities is obviously desirable.

[1] Light-coloured horses, white and dapple-grey, attract more *Hippobosca* than do dark ones.

II. **Hippobosca equina** L.

Geographical distribution and hosts: H. equina *L.* (Pl. IV, figs. 3 and 4).

Gruenberg (1907) mentions *H. equina* L. as occurring in Southern Europe, Asia, N. Africa and the Soenda Isles; Host: horse and cattle. Massonat (1909) found the same species in Southern France, Algeria and Tunisia, frequently on cattle, seldom on horses, often on dromedaries, seldom on dogs, and seldom on the birds (*Strix noctua* Bote and *Milvus regalis* Brix). Oudemans observed *H. equina* in Holland, occurring more frequently on horses than on cattle.

The collections at the Veterinary Laboratories prove that *H. equina* is found on Java, Madoera, Bali, Lombok, Soembawa, Flores, Saleyer, mainly parasitic on cattle, much less frequently on horses. In cases where cattle are absent horses may be heavily infested, as in the mountainous districts of Lombok and Saleyer. One specimen was captured on a pigeon.

Morphology. H. equina is smaller and more slender than *H. maculata* (compare figures on Plate IV), it has brown wings. Eyes black, frontal vitta orange, side stripes slightly brighter, adorned at each side with 2–3 vibrissal hairs. Two subequal yellow-brown hairs are at right and left hand of the clypeus. Two long hairs are found at the border of the vertex-plate. All 3 antennal hairs differ in size. Occiput thickly haired. The coloured plate illustrates distinctly the thorax pattern. I will mention however the following white spots separately:

(1) The "half star-shaped" spot, analogous with the median thorax-spot of *H. maculata*.

(2) A group of 3 spots, found on each side of the scutum from the wing-bases, and forward the "magnet-shaped" spot.

(3) A pair of ribbon-shaped spots, starting from the wing-bases but following a different direction.

Chaetotaxy. Two rows of prealar hairs, surrounding the largest spot of the "magnet" group. The first row contains 7 long hairs (4 median ones, black and thick, 3 lateral ones, yellow-brown and thinner). Second row, placed behind the mentioned spot, containing 2 thick, black and 7 short, yellow-brown hairs; lateral borders of scutum fringed with long, yellowish-brown hairs; 4 postalar hairs (the 2 central ones long and yellowish-brown, others short and black); 1 prescutellar long, yellow-brownish hair at each side; 5 bright yellowish-brown scutellar hairs; a row of short, thickly distributed, subscutellar hairs; the mesonotum bears at each side a row of 16 long and short yellowish-brown, ivory coloured hairs, parallel with the ribbon-shaped spot; borders of sternites are fringed with hairs.

Mesosternum with a row of 7 comparatively long hairs. Mesosternum with a row of 8 short and slightly longer hairs.

Wings pale brown, mediastinalis running in close connection with subcosta over the whole length. Subcosta and radius reaching costa at different spots. Halteres dull brown. Abdomen thickly haired. Male and female (Pl. IV, figs.

3 and 4) differ in the abdominal apex. Anal hill in the ♀ yellow, bordered brown-black, fringed with long yellowish-brown hairs. Adanal plates half-moon-shaped, their concave borders being attached to the anal promontory (Text-fig. II, 10). Preanal plates paired, round, visible on dorsal side of abdomen. Both sorts of plates covered with long, brown hairs.

Male (Text-fig. II, 9) presents two big, strongly haired, yellowish-brown, adanal plates, supporting the indentation of the abdomen. Last one exhibits a small promontory, hiding anal and genital openings. At its base at dorsum one finds a fringe of widely spread hairs.

The *pupa* of *H. equina* is smaller than that of *H. maculata*, and bears a bicornous spiracular plate.

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DESCRIPTION OF PLATE IV.

Fig. 1. *Hippobosca maculata* Leach. ♂.
Fig. 2. *H. maculata.* ♀.
Fig. 3. *Hippobosca equina.* ♂.
Fig. 4. *H. equina.* ♀.

Note: Prints of the plate and map accompanying Dr Stekhoven's paper were kindly supplied by the Director of the Veterinary Laboratories, Department of Agriculture, Buitenzorg.—Ed.

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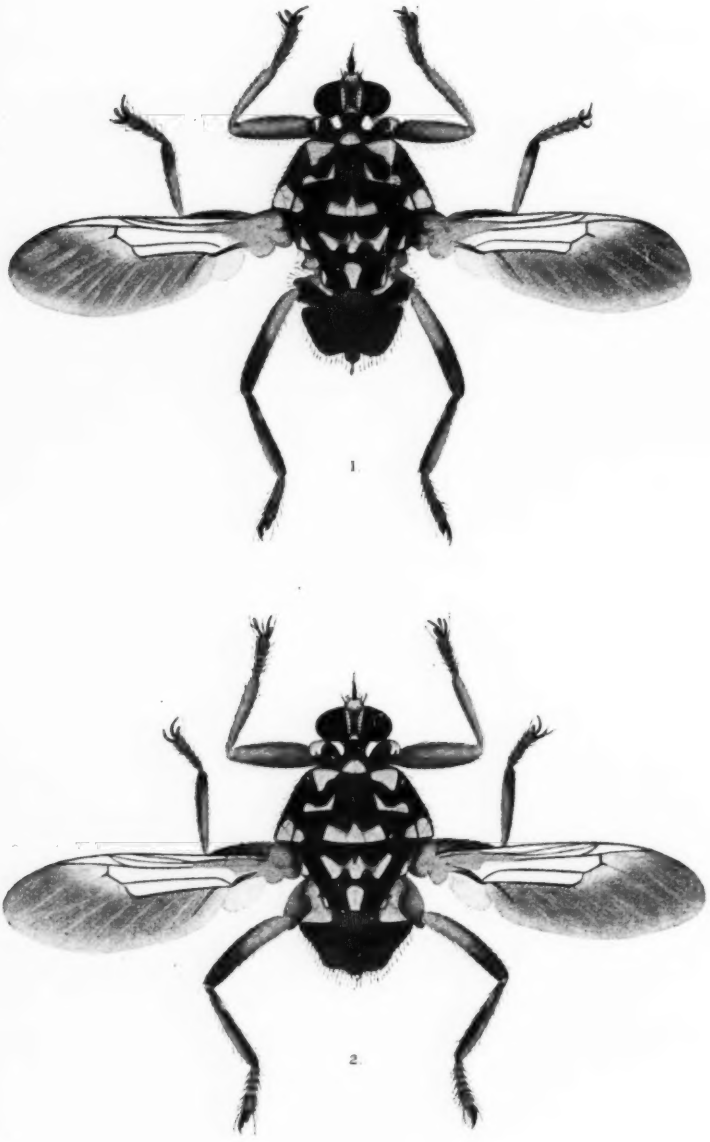

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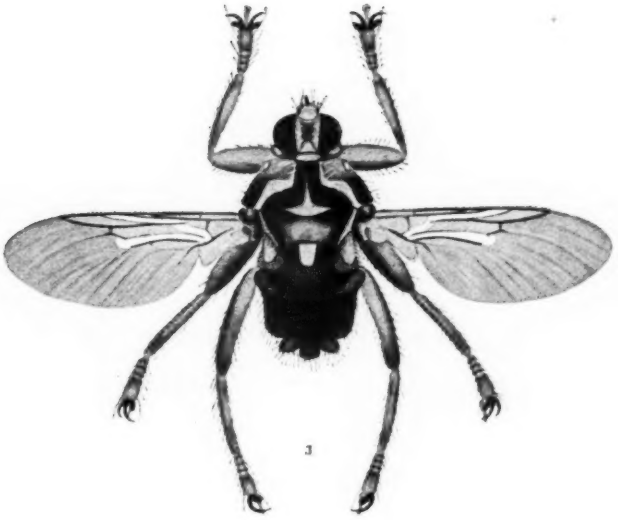
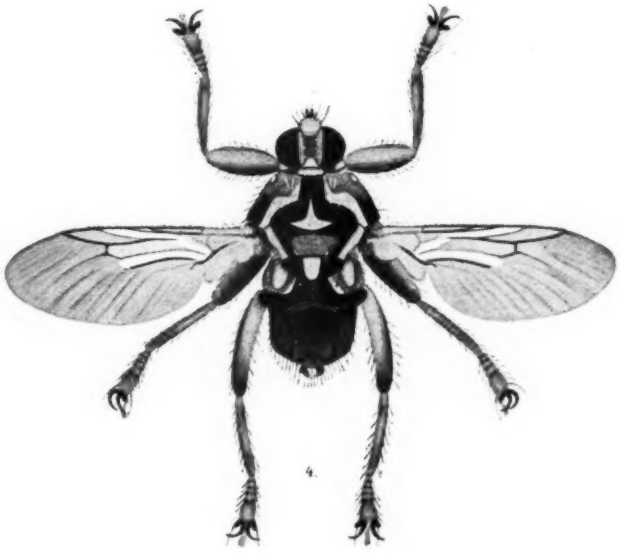
Hippobosca maculata Leach. (1) ♂. (2) ♀.





Hippobosca equina Linnaeus. (3) ♂. (4) ♀.

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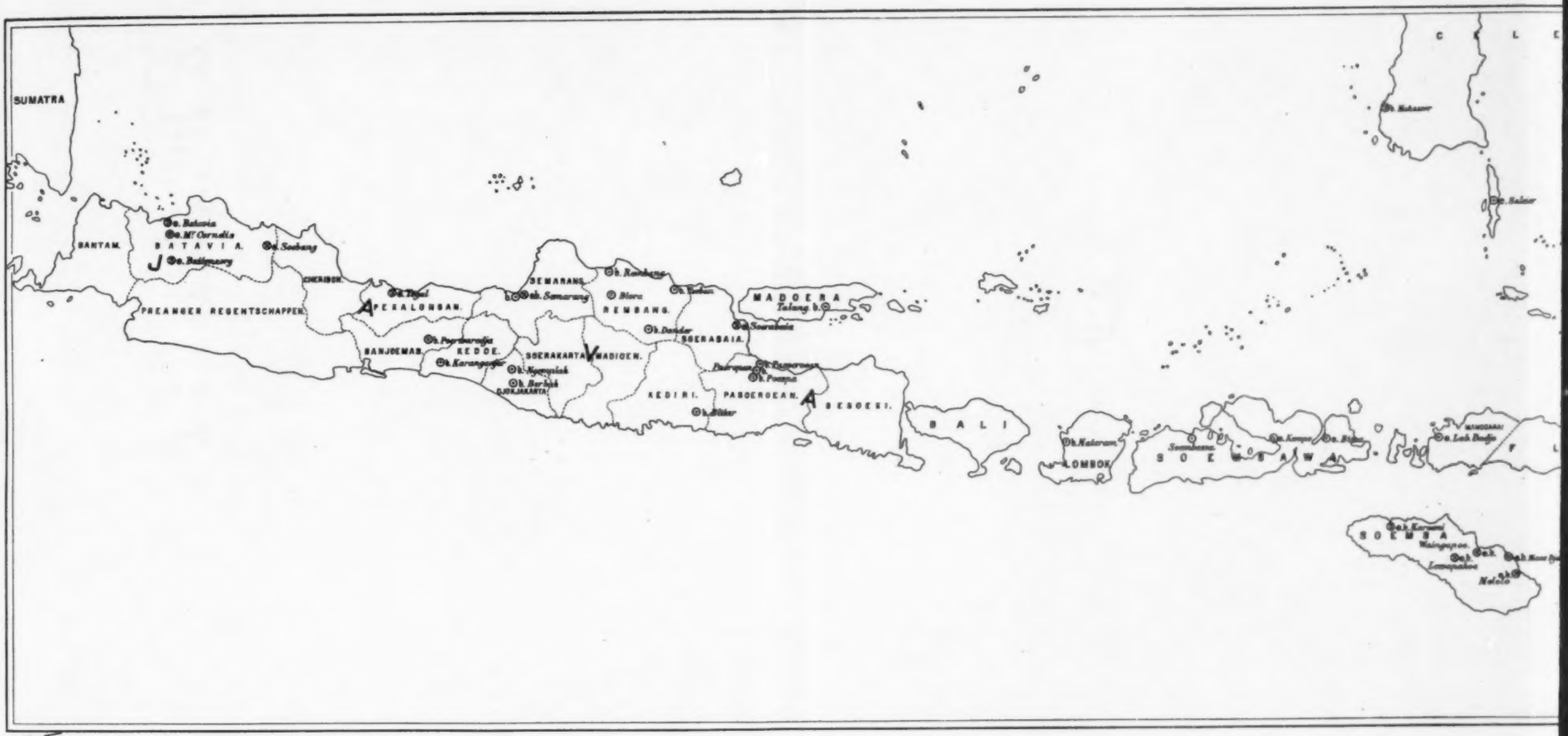


The Geographical Distribution of *Hippobosca maculata* (⊗) and *H. equina* (⊙) in the Dutch East Indian Archipela

Distribution of *Hippobosca maculata* (⊗) and *H. equina* (⊙) in the Dutch East Indian Archipelago.

BOETON
WETAR
ADONARA
ALOR
SOLOR
LOMBLEM
PANTAI
PORTUG.
SAVOE
ROTI

chipelago.

ON *MEGISTHANUS JACOBSONI* N.SP. (ACARI, GAMASOIDEA) PARASITIC ON A PASSALID BEETLE FROM SUMATRA.

By CECIL WARBURTON, M.A.

(*From the Molteno Institute for Research in Parasitology, University of Cambridge.*)

(With 8 Text-figures.)

Early in 1925 I received from Mr E. Jacobson a mite taken in 1918 from the Passalid beetle *Gnaphalocnemis* (*Eriocnemis*) *burmeisteri* Kaup. on the east coast of Sumatra. It clearly belonged to the genus *Megisthanus*, and was apparently new. I had described and figured it before I showed it to Mr Stanley Hirst of the British Museum (Natural History), South Kensington. He informed me that he had received both sexes of what he believed to be the same mite, and most kindly offered to hand over to me the material to complete my account of the new species. By the courtesy of Sir Sidney Harmer he was permitted to do this, and I have therefore been able to examine, as regards external features, four female and three male specimens.

In 1882 Thorell founded the genus *Megisthanus* for the reception of five mites—three from Java and two from New Guinea—which clearly belonged to no genus then established. The Javan species he named *caudatus* (type), *brachyurus* and *testudo*. He was uncertain of the sexes of his specimens, but regarded the form he named *caudatus* as a male, and suggested that *brachyurus* might eventually prove to be its female. As to the sex of *testudo* he says nothing.

Now, judging from the sexual aperture, there is little doubt that his *caudatus* and *brachyurus* specimens were both females and therefore in no danger of being fused into a single species, while his *testudo* is a male.

If we are right in considering the two forms now described as ♂ and ♀ of the same species, considerable light is thrown on the genus. There is obviously great sexual dimorphism. Where this occurs in Arachnids it is usual to find the male smaller and more divergent from the typical ordinal design than the female. In the present instance the male is the more massive, and much simpler in outline than the caudate female. It would appear quite likely that Thorell's *testudo* is the ♂ of either *caudatus* or *brachyurus*. The new ♀ bears a distinct resemblance to Thorell's type, *M. caudatus*, and the new ♂ is so similar to *M. testudo* that, had one to do with a less careful and exact observer than Thorell one might doubt whether it is specifically distinct. On close

examination, however, differences appear which could not have escaped that observer, and it is in the pointing out of these differences that its diagnosis will chiefly consist.

Megisthanus jacobsoni n.sp.

Male. Body ovate, 4·4 × 2·5 mm. Dorsum nearly covered by a yellow scutum bordered by a light band very narrow anteriorly and posteriorly, but widening at the sides, being broadest at the posterior third. (The dark band internal to this in *M. testudo* is absent.) The scutum is glabrous, but the light band bears posteriorly a fringe of uniform stiff white hairs. (In the dorsum of *M. testudo* hairs are found only near the rostrum.)

Venter (see Fig. 1) differs from that of *M. testudo* as follows. The genital plate is simply concave in front. The two obscure oval organs with central fovea noted by Thorell at the posterior end of the median ventral plate are present, but are contiguous. The anal plate is larger and more trapezoid than in *M. testudo*, and the light band separating the median ventral plates from the lateral plates is narrow and of fairly uniform width throughout. The lateral plates bear posteriorly numerous hairs somewhat finer than those of the posterior fringe. (The sexual aperture has the same structure—probably generic—as in *M. testudo*.)

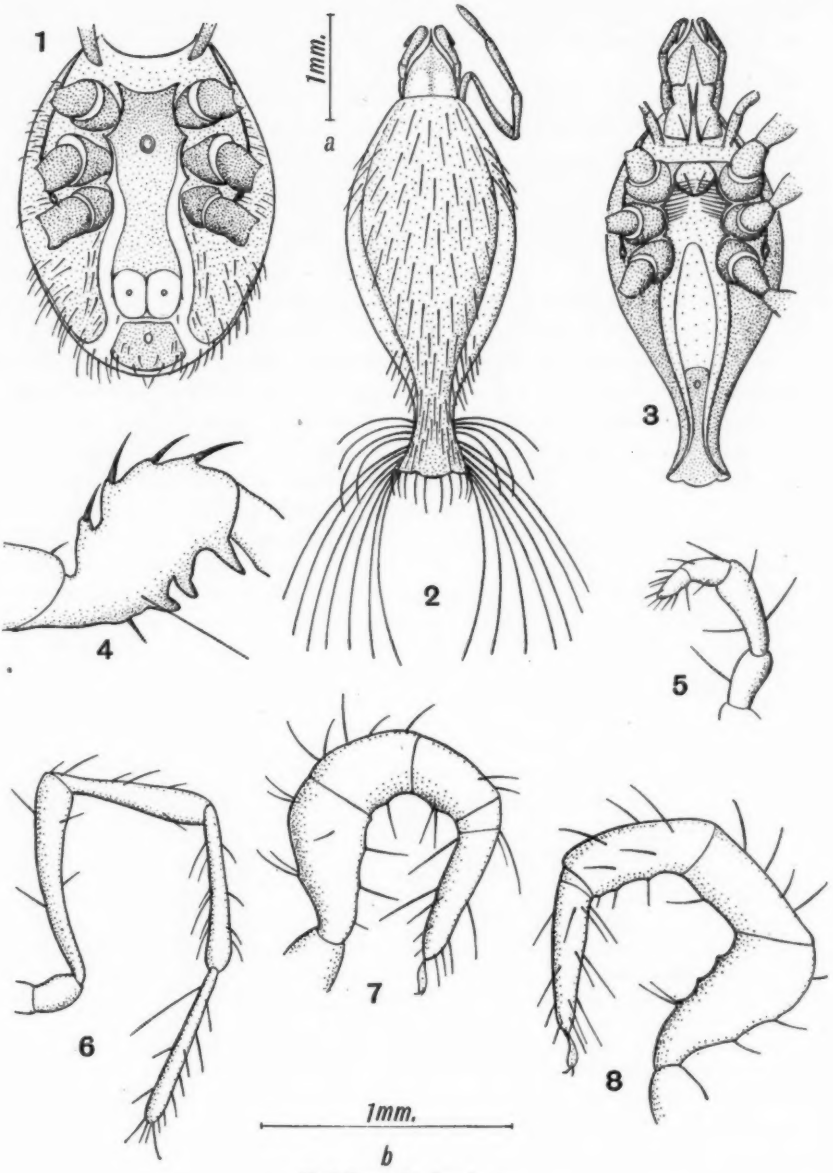
Legs. Apparently much as in *M. testudo* as far as can be made out from Thorell's figure and brief description. The femur of leg IV has at its base a stout recumbent dorsal spur bearing a strong bristle, and three other angular prominences with similar bristles on its more distal portion. Of the three stout ventral spurs two are near together at the base of the enlarged portion of the femur, and one at its truncated distal extremity (see Fig. 4).

Female. Body fish-shaped, 4·3 × 1·6 mm., broadest at the level of coxa IV, the posterior portion forming a "tail" which expands fan-wise for the last ½ mm. of its length and is faintly trifid at its extremity.

Dorsum. Slightly convex, the yellowish scutum leaving visible a paler-coloured band on either side except in the region of the "tail," which it entirely covers. The scutum bears numerous long semi-erect backwardly directed hairs, more numerous on the tail, which has in addition an armature of several very long stiff bristles. About seven especially long bristles proceed from the outer lobes of the trifid extremity on either side, while four, not so long, have their origin at the narrow region of the "tail." The sides of the body external to the scutum are for the most part glabrous, but in two regions (see Fig. 2) there are tufts of hairs similar to those on the scutum.

Capitulum. In general configuration closely resembling that of *M. caudatus*, but a specimen could not be sacrificed to examine the details of the chelicerae.

Venter (Fig. 3). Pale and, for the most part, glabrous. The broad genital operculum bears a pair of hairs, and there are about ten bristles proceeding from the bases of legs II and III on either side, directed medially. Median ventral scutum pale but fairly distinct. Anal scutum well chitinised, and



Megisthanus jacobsoni n.sp.

Fig. 1. Venter of male. Fig. 2. Dorsum of female.
Fig. 3. Venter of female. The mouth-parts are omitted from the camerostome. These three figures are drawn to scale *a*.
Fig. 4. Left femur of leg IV of male, seen from below.
Fig. 5. Palp of female. Fig. 6. Leg I of female.
Fig. 7. Leg II of female. Fig. 8. Leg IV of female.
The appendages, Figs. 4–8, are drawn to scale *b*. (H. C. G. *del.*)

following the shape of the "tail." Spiracle small, oval, on a level with the interval between coxae III and IV. Peritreme long, attaining the front of the body.

Described from 3 ♂s and 4 ♀s from Sumatra. The first specimen I received was a ♀ sent by Mr E. Jacobson, after whom I have named the species. It was taken on *Gnaphalocnemis* (*Eriocnemis*) *burmeisteri* Kaup., a Passalid beetle, on the east coast of Sumatra, in January 1918. The British Museum specimens are in two tubes (1 ♀ in one tube and 3 ♂s and 3 ♀s in the other) labelled "Sungei Kumbang 4600 ft. Korinchi Hill Country, Sumatra. Robinson and Kloss, April 1914."

Mr Jacobson's type of the ♀ is to be deposited in the Leyden Museum. The ♂ type and ♂ and ♀ co-types are in the British Museum of Natural History.

Since Thorell founded the genus in 1882 more than a dozen species have been added from forms discovered in various parts of the world. In different numbers of *Redia* Berlese has described two species from Central America, two from W. Africa, one from Australia, and three from New Caledonia. Kramer (1895) described a species from Central Africa; Canestrini one from Burma, Oudemans two from New Guinea, and Banks one from Florida, so that the genus seems to be widely spread in the torrid regions of the world. Most of the specimens appear to have been unattached to any host, but it is interesting that Berlese's Australian species *M. modestus* was also found on a Passalid beetle.

Of all the forms hitherto described the female of the present species is the one which most closely resembles the type *M. caudatus*, which was taken in Java.

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(*MS. received for publication* 27. VIII. 1925.—Ed.)

ON THREE NEW SPECIES OF TICKS (ARACHNIDA, IXODOIDEA), *ORNITHODORUS GURNEYI, IXODES ARVICOLAE* AND *HAEMAPHYSALIS MJÖBERGI.*

By CECIL WARBURTON, M.A.

(*From the Molteno Institute for Research in Parasitology, University of Cambridge*).

(With 3 Text-figures.)

Ornithodorus gurneyi n. sp.

Broadly oval, 5·8 × 3·9 mm., slightly broader at the posterior third; rounded in front, the posterior border more flattened. Integument mammillate and with dorsal depressions and discs, and ventral grooves strongly recalling *O. coriaceus* (see Fig. 1). Numerous short white hairs scattered over the integument, and notably a ring of close-set clavate hairs round the base of each trochanter. Eyes absent. The half-gorged ♂ measures 6 × 4 mm.

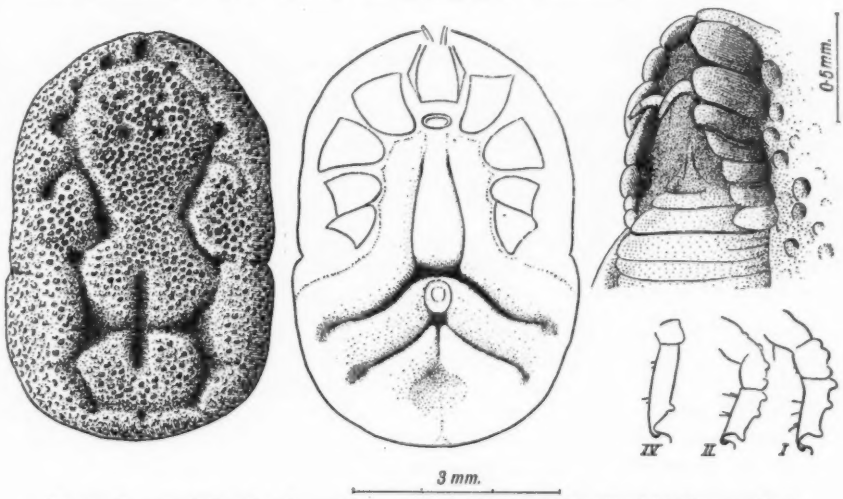

Fig. 1. *O. gurneyi*, dorsal and ventral aspect, tarsi I, II and IV. Hood highly magnified. (H. C. G. *del.*)

Capitulum small and apparently entirely retractile within the hood, which is of composite structure, having a separate anterior piece followed by a free side piece and completed by a movable "cheek" marked by furrows into distinct portions (Fig. 1). Palps pale, with a few rather long dorsal hairs. Hypostome almost devoid of teeth.

Legs pale—especially the distal joints, which bear characteristic protuberances (see Fig. 1). Tarsus IV has the false articulation slightly prominent, and a small distinct distal hump.

Described from two specimens taken in an old shed at Tibboburra, N.S.W., 24. XI. 1922, by Mr W. B. Gurney, and sent with other ticks by the Government Entomologist of N.S.W. in 1924 to the Imperial Bureau of Entomology, where it was numbered 1378. One is a male and the other apparently a nymph, but they entirely resemble each other except that the male has the sexual aperture and a more developed hood. On July 14, 1924, Mr L. E. Cooling sent us three (slide) specimens of what is evidently the same tick. They were taken on the ground at Sesbania, Corfield, Queensland, near small trees where kangaroos camped, but no examples were found on kangaroos or on sheep.

Ixodes arvicolae n. sp.

MALE unknown.

FEMALE. *Scutum* oval, much longer than broad, 1·25 × ·87 mm.; cervical grooves almost obsolete; lateral grooves rectilinear, only slightly divergent, cutting off a lateral ridge of darker colour than the rest of the scutum;

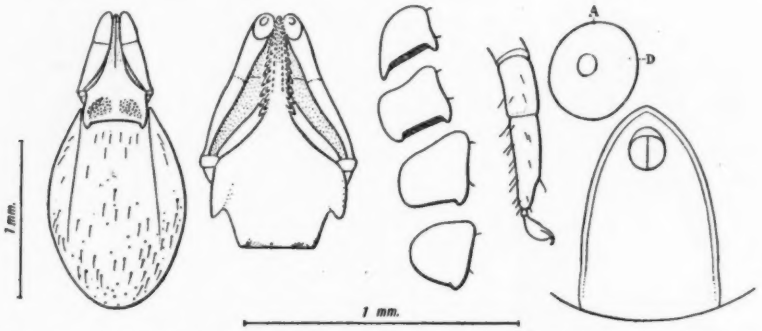

Fig. 2. *I. arvicolae*, ♀; capitulum and scutum in dorsal aspect. Coxae, tarsus IV, spiracle (*A* = anterior, *D* = dorsal) and anal groove. (H. C. G. *del.*)

punctations small, shallow and inconspicuous except in the posterior region and on the lateral ridges; emargination deep; scapular angles long and sharp. In un-rubbed specimens the scutum shows a sparse sprinkling of short hairs.

Venter: vulva between coxae IV; anus very posterior, with short anal grooves, ogival in front and only slightly divergent behind; spiracle comparatively very large (0·35 mm.), much larger than coxa IV, broad oval, the stigma somewhat central.

Capitulum: basis long, with short sharp cornua; porose areas large, ill-defined, roughened patches; auriculae rather flat, bluntly angular posteriorly. The posterior end of the basis, in its ventral aspect, shows two minute postero-

lateral prominences. Hypostome long, uniformly tapering. On either side there are two rows of large teeth, about eight teeth per row; within these double rows there are two rows of small teeth extending for about $\frac{2}{3}$ the length of the hypostome, and within these, in the anterior region, yet another pair of rows of very small teeth, so that after the small corona the dentition is at first 4|4, then 3|3, and finally 2|2. Palps long.

Legs: coxae comparatively large; coxa I with two short, sharp, equal spurs separated by a straight, trenchant, dark-coloured border; coxae II and III trenchant, with a slight external spur; coxa IV has a similar external spur, but its posterior border is curved. Tarsus IV rather long, cylindrical, tapering rather abruptly at the end, without spurs, but beset below with a double row of regular short bristles.

Described from four specimens taken by Miss G. E. Pickford and Mr G. E. Hutchinson on water-voles, *Arvicola amphibius amphibius*, at Quy, near Cambridge, in May 1925. One specimen was in company with *I. tenuirostris*. Type at Cambridge.

Note. In 1901 Neumann (*Révision de la Famille des Ixodidés*, p. 161) described a tick taken from *Mus agrarius* at Genoa by C. Parona, under the name of *Ixodes acuminatus*. Its occurrence has not since been recorded by any writer as far as I am aware. The present species has several points in agreement with Neumann's description of *I. acuminatus*, and its specific difference was at first doubtful. By the great kindness of Prof. A Martin of the *École vétérinaire de Toulouse* I have been enabled to examine his type specimen. It is clearly not the one of the two original specimens figured by Neumann, for it is gorged and unfortunately mutilated, having lost its hypostome and most of its legs. Prof. E. Brumpt of the *Laboratoire de Parasitologie*, Paris, has taken near Rennes specimens of what he believes to be Neumann's *I. acuminatus*, and he has been good enough to compare with them an example of the tick here described, and to discuss the matter with Dr Larousse, and their opinion is that *I. arvicolae* is undoubtedly a distinct species. The most obvious differences concern coxa I, the spiracle, and the porose areas. In *I. acuminatus* the inner spur of coxa I is much longer than the outer, and the border between them is concave. The spiracle of *I. arvicolae* is remarkably large—much larger than coxa IV. The porose areas, instead of being "circular, widely separated," are ill-defined and rather near together.

N.B. It is possible that this is the female of *I. apronophorus*, described by P. Schultze in March, 1924 (*Zool. Anzeiger*, LIX) from a male and three nymphs taken in a nest containing young voles at Kremmener Luch, Brandenburg.

Haemaphysalis mjöbergi n. sp.

MALE. *Scutum* rather broadly oval—2·3 × 1·6 mm. (in larger specimen)—glossy, uniformly pitted with small shallow punctations, and with a fairly well-marked nearly circular pseudo-scutum. Cervical grooves short, ill-defined

depressions; lateral grooves shallow at first but suddenly deepening at the level of legs III and enclosing two festoons. Festoons medium, punctate like the rest of the surface.

Capitulum: basis large, rectangular, broader than long, with strong cornua; palps short, equal in length to basis, article 2 moderately salient laterally and twice as long as article 3. No dorsal spurs; a moderate ventral spur on article 3, a blunt projection under article 2. Dentition 5|5.

Venter: spiracle large (0·3 mm. long), sub-rectangular, with stigma near anterior border.

Legs: a sharp, fairly long internal spur on coxae I and IV; shorter internal

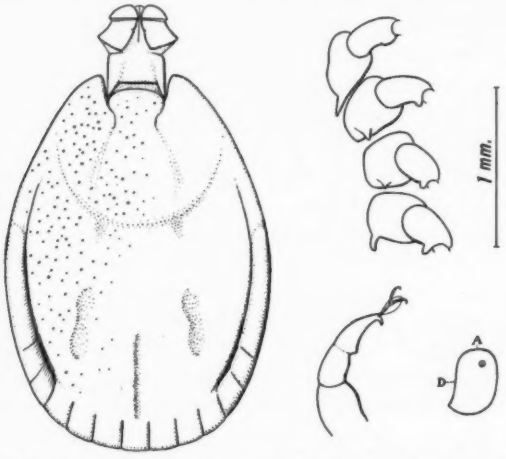

Fig. 3. *H. mjöbergi*, ♂, dorsal aspect, coxae and trochanters, tarsus IV and spiracle (*A* = anterior, *D* = dorsal). (H. C. G. *del.*).

spurs on coxae II and III. Trochantal spurs present but inconspicuous, increasing from I to IV. Tarsus IV small, tapering rapidly.

FEMALE unknown.

Described from two specimens in a tube labelled "Rissa equina, Borneo," in a small collection of ticks sent by Dr E. Mjöberg from Sarawak, 7. IV. 24.

This fine species has some resemblance to *H. montgomeryi*, but it is less hairy and the capitulum is differently shaped, article 3 of the palps being more salient laterally, and article 2 lacking the sharp ventral spur.

(*MS. received for publication* 8. VIII. 1925.—Ed.)

NAOBRANCHIA STIBARA N. SP., A PARASITIC COPEPOD OF *CHILOMYCTERUS SPINOSUS*.

By W. HAROLD LEIGH-SHARPE, M.Sc. (Lond.).

(With 3 Text-figures.)

Habitat and Record. Six females, three of which were adult and of equal size and the rest small and imperfect, of a new species of *Naobranchia*, easily recognisable as being the only one as yet described in which the cephalothorax is definitely shorter than the trunk, were taken by L. Harrison Matthews on 7 viii. 1923 during his visit to Brazil, at Praia de Icarahy, Rio de Janeiro, on the gills of the Diodontid globe-fish *Chilomycterus spinosus*.

Body. The general form is depicted in Fig. 1. The total length of the animal is 4·6 mm., which would extend to 5 mm. if the ventrally-curved anterior end were straightened out, of which the cephalothorax occupies 1·6 mm. and the trunk 3 mm. The trunk is nearly as broad as it is long, its greatest width towards the posterior end being 2·6 mm. The whole preserved animal, including the 2nd maxillae, is pure white, except the egg-sacs which are dark yellowish-brown. The eggs are large, fifteen in a row with a total breadth of six rows, in dorsal aspect agreeing with *N. lizae*. The ovisacs are turned forward along the lateral margins of the trunk and covered completely and held in place by a transparent membrane, which is strengthened by a rib (Figs. 1 B and 2) which runs along the middle line of the outer surface, turns dorsally at the posterior end, runs forward a little way, and then turns inward to the median dorsal surface of the trunk (Fig. 2) and merges into the mid-dorsal ridge which is raised into a more pronounced hump than in other species. The anus is situated as in *N. lizae*.

Cephalothorax. Head very small, curved under anteriorly, neither enlarged nor separated from neck (Fig. 1 C). I am unable to make out a dorsal carapace, and am doubtful as regards the lateral palps.

Neck. Not particularly slender, and separated from the trunk by two semi-annular enlargements on the dorsal side with a deep groove between them.

The Second Maxillae do not arise from so pronounced a base as in other species. Dr Charles Branch Wilson has found (*a*) that each band represents a separate maxilla, (*b*) that they are anterior and posterior instead of left and right, (*c*) that both bands start on the mid-ventral line of the cephalothorax and extend round a single gill-filament from the left to the right side of the parasite, (*d*) that on the animal's right side and sunk below the surface of the cephalothorax are two sockets into which the blunt claws on the tips of the

maxillae fit, (*e*) that the claws and sockets are gradually fused together until in the adult they are usually not separable. I am able in part to confirm this, since in the two best specimens the more posterior of the maxillae, which is morphologically that of the right side, is not attached to the body, and although I cannot make out that it is broken, yet I fail to detect any interlocking claw.

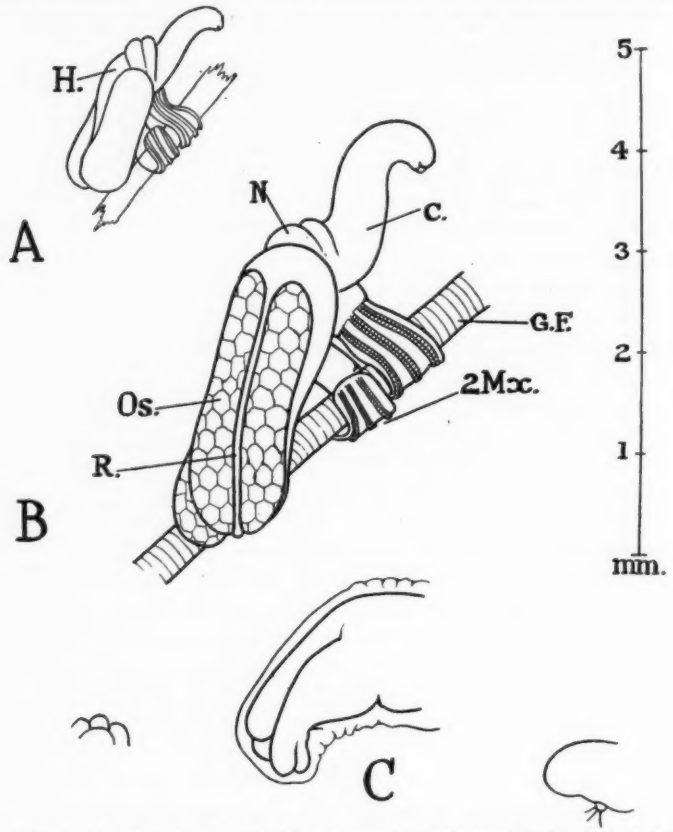

Fig. 1. *Naobranchia stibara* ♀. B and A, lateral aspects from different angles; *C*, cephalothorax; *N*, base of neck; *H*, hump; *G.F*, gill-filament; 2 *Mx*, second maxillae; *Os*, ovisacs; *R*, rib. C, lateral aspect of head.

Though I have sacrificed two of the best specimens, I have not been able to make out the anterior appendages, but behind the region in which they presumably are lie cells of peculiar aspect and large size (Fig. 3).

Specific characters ♀. Cephalothorax plainly shorter than trunk. Head curved anteriorly. Base of neck with two large semi-annular swellings dorsally with a deep groove between them. Base of second maxillae not prominent. Mid-dorsal line of trunk with a ridge and a pronounced hump.

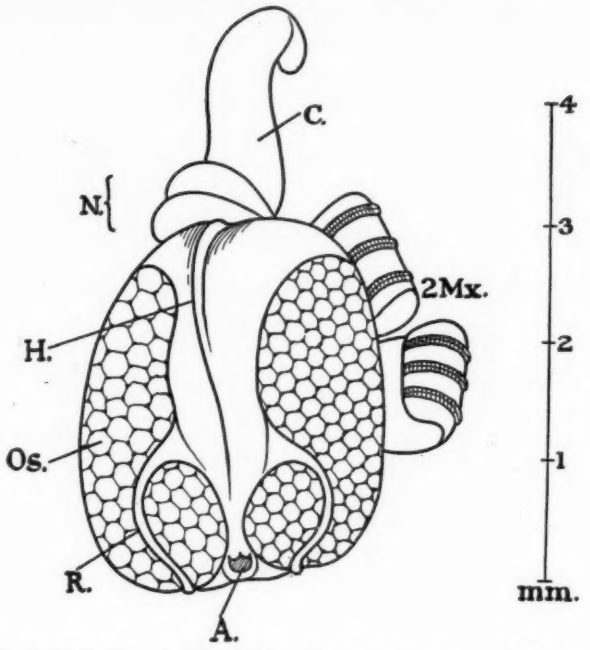

Fig. 2. *Naobranchia stibara* ♀. Trunk in dorsal aspect. Lettering as in Fig. 1. *A*, anus.

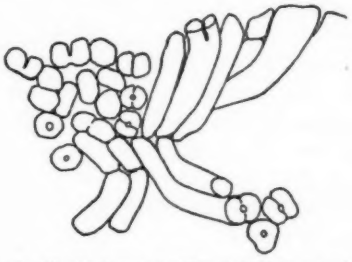

Fig. 3. *Naobranchia stibara* ♀. Ventral aspect of head, highly magnified, showing peculiar cells.

It is interesting to note that Brian (1924)[1] has recently described new species of *Naobranchia* from the Mediterranean, one of which was also from a globe-fish, in this case Tetrodont, *N. variabilis* from *Tetrodon laevigatus* at Port-Etienne.

[1] *Parasitologia Mauritanica, extrait du Bulletin du comité d'études historiques et scientifiques de l'Afrique occidentale française.* No. de juillet-septembre, 1924, p. 57.

(*MS. received for publication* 7. IX. 1925.—Ed.)

SIMPLE TYPES OF A MUSEUM CASE AND A STAND FOR EXHIBITION OF LANTERN-SLIDES.

By G. H. F. NUTTALL, F.R.S.

(*From the Molteno Institute for Research in Parasitology.*)

(With Plate V and 2 Text-figures.)

Several visitors to the Molteno Institute having expressed a wish for a description of certain cases in our Museum, and believing that the types of cases I have devised, with the aid of a local carpenter, may appeal to others desiring inexpensive cases or stands for similar purposes, I herewith append an account of them. The cases are intended for the reception of specimens that are not frequently shifted about.

I. *Vertical case glazed on both sides, suited for exhibition of small objects, drawings, photographs, etc.*

(Fig. 1 and Plate V.)

The case consists of a framework of which the essential features are illustrated in Fig. 1. The vertical sides of the framework (*a*, *a*) are each mortised and pinned in four places, three of which are indicated by points in the figure, (1) at the joint with the solid feet (*b*, *b* two pins each), (2) at the joints with the horizontal pieces (*c*), (*f*, *f*) and (*d*, *d*, where they are concealed) fixed by single pins. A stout upright (*e*) mortised and pinned to (*c*) bisects the case vertically, the upper portion being slender and concealed by the two glazed frames (*d*, *d'*) in Fig. 1 **A**. The horizontal (*f*, *f*) consists of two sections each mortised and pinned to upright (*e*). Vertical matchboard partitions (see Fig. 1 **B** at *m*) form the back of the case to which objects are attached; the matchboard is held in place by grooves in the vertical supports (Fig. 1 **C**, **D**). The top of the case is formed of a single board screwed to the frame-work; its rounded edges protrude slightly as a cornice. The glazed frames, of which there are four (two per side), fit snugly in the case, each being firmly held in place (locked) by four long brass screws (*s*, *s*) which pass through countersunk brass rings in the front of the frame to enter the vertical supports. When the screws are drawn from the glazed frames the latter are readily removed from the case and replaced by grasping the metal handles (**H**) which are fixed midway at the top and bottom of the frames (near *d*, *d'* in Fig. 1 **A**).

The detail drawings Fig. 1 **C** and **D** show the construction of the closed case in horizontal cross-section at *a*–*a*, (**C**) representing one side and (**D**) the

middle. The glazed frames, each of which contains a single sheet of glass, are $1\frac{1}{2}$″ deep and, when screwed in position, afford a dustproof closure. The matchboarding is covered by grey wall-paper held in place by pins and the objects screwed to the board. To protect certain objects exhibited from over-

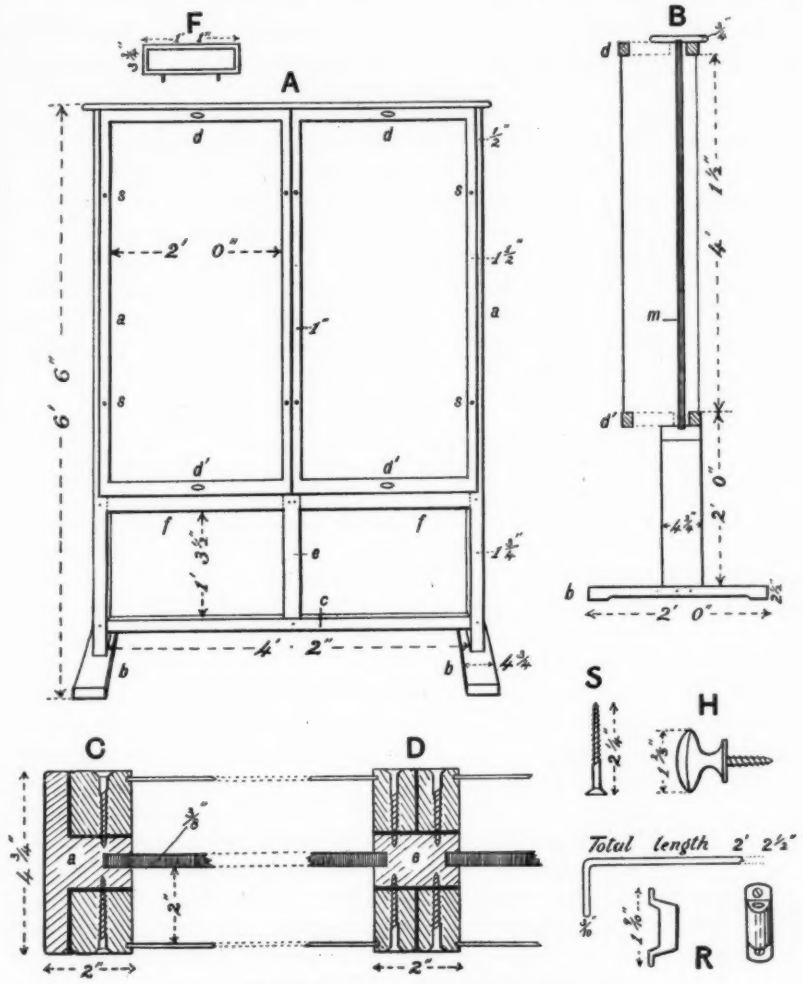

Fig. 1. Museum Case. (H. C. G. *del.*)

exposure to light, I have used black sateen curtains (double thickness if needed), these hanging flat from a steel rod (**R**) which is bent like an L at one end so as to hinge in a brass socket (as figured) fixed on the outer side of the case near the top (Pl. V). The rod is passed through a hem in the curtain and

small holes drilled through the rod near the ends allow of the curtain being stitched taut to the rod. When swung to, the rod is held in position by lifting the free end slightly over a small brass L hook (screwed into the frame near the top and centre of the case, close to where the rod ends) when the curtain closes over the case.

Our cases measure 6′ 6″ in height by 4′ 5″ in width, the surface of each glazed frame being 2′ wide and 4′ 2″ high, extending from 2′ 2″ above the floor to a height of 6′ 4″. The latter measurements (fractions of an inch excluded) appear suited for persons of average size desiring to examine the contents of the cases without unduly stooping or craning their necks. *Measurements* accompany the drawings. Obviously the depth, size, and locking arrangements may be modified to suit requirements, thus screws turned by a key and entering metal nuts fixed in the framework may be substituted for ordinary screws penetrating the wood.

Plate V shows one of our cases containing a part of the mycological exhibit consisting of illustrations and cultures. The black sateen curtain is shown hinged back on the left; the steel rod and curtain have been removed from the opposite side showing the position of the socket.

II. *Vertical Stand for exhibiting lantern slides.*

(Fig. 2 and Plate V.)

The stand (Fig. 2) consists of a framework whose main component parts are mortised and pinned in a manner similar to those in the case previously described, but the structure is lighter. The stand is designed to support a series of long and narrow wooden frames (**E**), six on each side, each frame enclosing ten lantern-slides of the standard pattern used in this country ($3\frac{1}{4}'' \times 3\frac{1}{4}''$), therefore each stand serves to exhibit 120 lantern-slides as shown in Pl. V. The frames slide into position through a cleft of corresponding size at the outside upper part of the uprights (Fig. 2 **A**, *a*, *a* and **B**), and are held in position by corresponding grooves to the right and left of the upper portion of upright (*e*). The lowermost frame is first introduced, and the others follow in succession until the topmost frame is pushed home and completes the set of one side (Fig. 2 **A** shows how frame **E** slides into position). Small pegs are now inserted into corresponding holes in the frame at the ends near uprights (*a*), the pegs bolting them in place. The frames rest upon each other and their combined weight is supported by the horizontal (*d*). The cleft which admits the frames is closed by a strip of wood (B) of corresponding size and somewhat T-shaped in cross-section (the stem of the T fitting into the cleft, the cross-piece acting as cap, see Fig. 2 **C** B). At the back of the stand (Fig. 2 **A**′), over the area occupied by the frames, a piece of ground glass (G) is inserted to diffuse the light falling through the lantern-slides from a window or artificial source of light. The uprights (*a*, *e*, *a*) and the horizontals (*d*, *d*), are grooved for the reception of the glass. A single board with rounded edges

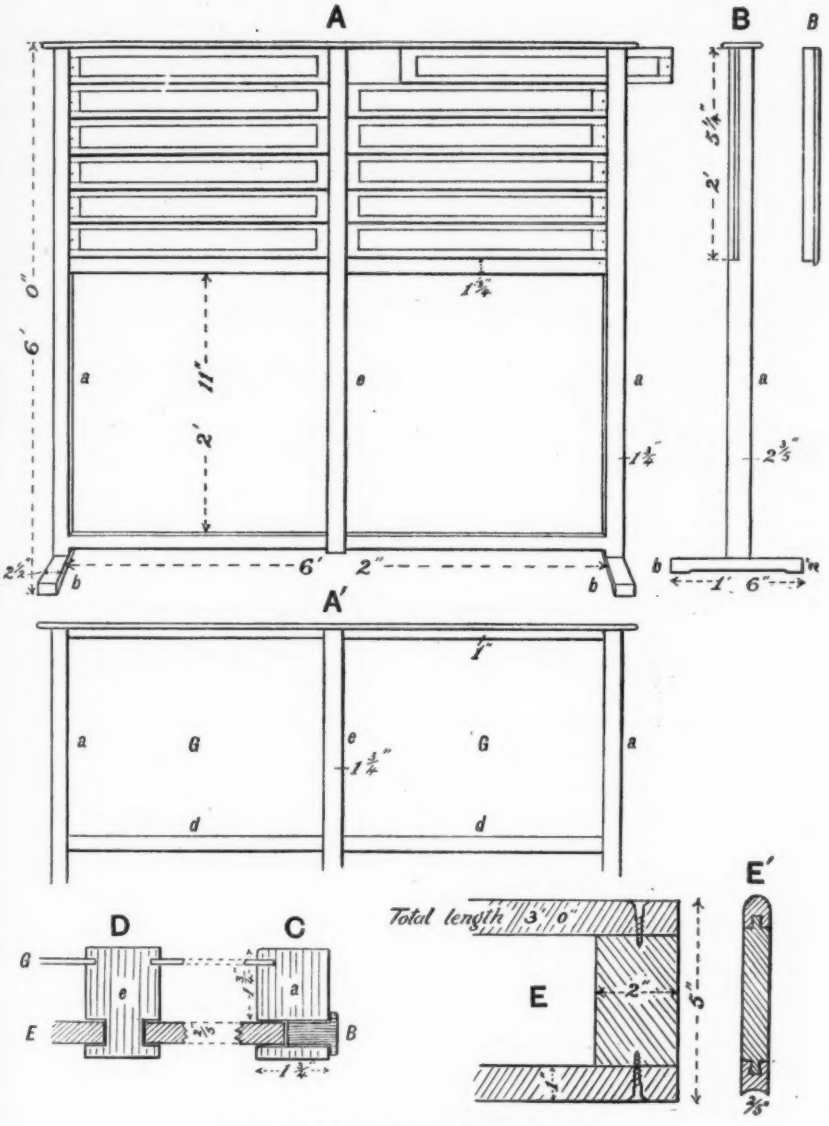

Fig. 2. Lantern-slide Stand. (H. C. G. *del.*)

serves as a top and is screwed to the three uprights. Narrow strips of wood on its underside serve to cut off any light that penetrates between the top and the uppermost frame. The frames are grooved inside along their whole length and at both ends. (Detail in Fig. 2 **E**, **E'**). The upper and lower margins of the frame are slightly convex and concave respectively (as shown in Fig. 2 **E'**) so that no light passes through the space between the superposed frames as it does when the margins are flat. At the outer end, the end-piece, whilst mortised, is held in place by two long thin screws. To fill the frame with lantern-slides the screws are withdrawn, the end-piece removed and the slides are slipped in place along the grooves in the frame. When the frame is filled the end-piece is replaced and screwed fast. *Measurements* accompany the drawings. Neatly written labels, uniformly disposed and placed beneath the glass of the lantern slides, render the appearance of the exhibit attractive.

To serve as a guide to the contents of the museum cases and stands, oblong frames (Fig. 1 **F**) are placed at the top of each section. These frames are shown in position in Plate V. The card bearing the inscription is attached to the glass by passepartout, placed in the frame, and backed by a thin three-ply board which is held in place by pin nails. The advantage of passepartout is that it excludes minute insects (especially *Thryps*, very prevalent with us) and dust. On the underside of the frames, two headless screws project which fit loosely into corresponding holes at the top of the case. The screws and holes are all equidistant from one another and consequently allow for the frames to be shifted from one position to another on the cases. The frames are of blackened oak and of simple standard pattern of moulding.

Materials: Except for the frames holding the lantern-slides[1] (made of mahogany), and the frames fixed to the tops of cases and stands (made of oak), all the woodwork consists of pine. All exposed angles are rounded off and all the wood surfaces are blackened and dull polished. The glazed frames in the cases consist of good 32 ounce glass.

Cost: The cases, as described and figured, have cost us £9 each complete. The stand, including 12 frames for lantern-slides (7*s*. 6*d*. each), cost us £8. Rods, fitments and curtains to certain cases, cost per case (8 sections) 17*s*. 9*d*.

[1] The frames as figured are $\frac{3}{8}$″ thick, latterly we have had them made $\frac{1}{4}$″ thick.

Stand for Lantern-slides

Museum Case

UNIV. OF MICH.

A DISCUSSION ON *TRYPANOSOMA RHODESIENSE.*

By H. LYNDHURST DUKE, O.B.E., M.D., Sc.D.

Bacteriologist, Uganda Protectorate.

In a paper published in July 1924, Professor Brumpt has done me good service by criticising certain views of mine on the epidemiology of human trypanosomiasis (Brumpt, 1924).

For various reasons I have only recently had an opportunity of studying this paper. Some of the criticisms it contains are unanswerable; others can be met; others, again, rest upon a misunderstanding of my various contributions to *Parasitology* on the affinities of the polymorphic trypanosomes.

In attacking the problem before us a free interchange of views is of the greatest value, and this critique is a welcome step in the right direction. The debate is open, and many points still await elucidation. The issues are important and involve, as Professor Brumpt says, "de graves problèmes de prophylaxie."

In the following pages I shall attempt to meet some of Professor Brumpt's criticisms, and, at the same time, to remove certain misconceptions for which I do not wish to be held responsible.

It will be convenient to take in order the formal conclusions of the paper, weighing each in turn and considering the evidence and inferences brought forward in their support.

Conclusion 1. "Le *Trypanosoma rhodesiense* ainsi qu'il résulte des recherches épidémiologiques récentes est à notre avis une bonne espèce."

This is the main conclusion of the paper to which the others lead. But what are the recent epidemiological researches which point to this conclusion? On page 262, Brumpt admits that, at times, epidemiological studies and statistics appear to support the view that occasionally man may contract nagana.

He then passes on to a consideration of the figures that I obtained in the Mwanza area in 1922. From these figures, he says, we may assume an annual mortality, in the Mwanza area, of from 2–20 per cent. due to *T. rhodesiense.* That is to say, of 100 individuals subjected to infection 2–20 are receptive to *T. rhodesiense.*

Examining, in the light of these figures, Taute and Huber's human inoculation experiments with nagana Brumpt argues that if their trypanosome had

been *T. rhodesiense*, from 3–27 of those inoculated "auraient pu contracter la maladie naturelle à *T. rhodesiense* à Mwanza." From this he infers that Taute's conclusion that *T. rhodesiense* and *T. brucei* are different species receives confirmation from the evidence accumulated at Mwanza.

I confess I cannot accept Professor Brumpt's reasoning. Taute's experiments were performed with *T. brucei* derived from a region where *T. rhodesiense* did not exist—where, in other words, and according to my view, the stimulus necessary to induce *T. brucei* to cultivate man as a host was lacking.

In the Mwanza area, conditions were quite different. A serious famine, influenza, and ankylostomiasis, had paved the way for a reduction of the game, and thrown a man-loving tsetse, *G. swynnertoni*, into extremely close contact with a debilitated native population. When my figures were obtained, the epidemic had been going on for a considerable time and the trypanosome was well established in man. The Mwanza outbreak was, indeed, the first recorded instance of an *epidemic* due to *T. rhodesiense*.

Statistics acquired under such conditions obviously cannot be applied unreservedly to Taute's results, obtained in an area where the peculiar conditions prevailing at Mwanza were non-existent.

Professor Brumpt debits me (p. 263, l. 21) with the opinion that "la très grande réceptivité de l'homme dans la région de Mwanza est due à un affaiblissement de l'organisme par la famine et par l'ankylostomose."

My contention is, rather, that the famine and the influenza, aided no doubt by the ankylostomiasis, paved the way for *T. brucei to obtain a footing in man*; and that these debilitating influences were intimately associated with an increased attack on man by hungry tsetses, whose normal food supply, the wild game of the belt, had been greatly reduced by indiscriminate hunting.

The great receptivity of man *at the time of my visit two years later* was due to the adjustment of the parasite to man during the interim.

The trypanosome had by this time become thoroughly "humanised," possibly even to the extent of becoming cyclically transmissible from man to man by the tsetse. For it must be remembered that even under the strictly controlled conditions of experiment possible at the laboratory, direct transmission may, and probably must operate for many months before a strain loses the power to develop in the fly.

The famine and pestilence played an important part in the establishment of the trypanosome in man's blood, at the very onset of the epidemic. They also ensured the "gravité de l'affection" (p. 263, l. 30), essential for the free operation of direct transmission; for the heavier the infestation of the peripheral blood with trypanosomes, the easier the transmission of the parasite by the mechanical method.

What recent researches do show is that wherever cases of *T. rhodesiense* occur, *T. brucei* is present in the tsetse and in the game.

Recent information seems, indeed, to indicate that wherever game tsetses and man are in broad contact, *T. rhodesiense* will be found.

The statement made in the last paragraph of p. 260 that "Par contre aucune infection pouvant être rapportée à un trypanosome du type *T. rhodesiense* n'a été signalée dans les nombreuses régions d'Afrique où abondent le *T. brucei* (= *T. pecaudi*)" is so contrary to experience that it is only explicable as the result of a typographical error.

Conclusion 2. "La classification des trypanosomes doit être basée sur l'ensemble de leurs caractères morphologiques et biologiques."

Agreed, provided we remember that "biological" characters, such as virulence and host proclivities, are essentially variable *physiological* characters, which are not yet understood.

My protest against the separation of *T. brucei* from *T. rhodesiense* is that hitherto the distinction rests solely on a single physiological character, whereas the balance of the "ensemble" of *all* biological (morphological and physiological) characters favours the conclusion that the two are only strains or varieties of a single species.

Conclusion 3. "L'immunité naturelle de certaines espèces d'hôtes vis-à-vis de l'infection naturelle est un caractère d'une grande valeur et constitue pour nous, en l'absence d'autres, un excellent critérium pour individualiser certaines espèces."

Agreed that considerable importance attaches to natural immunity of certain species of hosts against natural infection: the distribution of trypanosomes in nature must be greatly influenced by this factor. But what do we know at the present time about either natural immunity or natural infection? The little we do know certainly does not justify the employment of this test as a criterion of species.

The study of the trypanosomes of mammals in relation to their blood-hosts is fraught with innumerable complications. There are differences between individuals of the same species of mammal, differences that depend either on qualities inherent in the animal or on the influence of "bien-être." Different races of a mammalian species may react differently towards a trypanosome.

For example, there is the occasional susceptibility of baboons and mangabeys to trypanosomes against which these animals are usually immune. This phenomenon may be equally well ascribed to the host or to the parasite or to both.

Once we introduce man into the discussion, difficulties multiply enormously, because man himself is outside the reach of actual experiment. Do Macfie's case of *T. vivax* in man and Professor Lanfranchi's mysterious infection in Italy justify a re-christening of these two strains of trypanosomes?

In arriving at this conclusion, Brumpt discusses the value of the behaviour of the trypanosome in the intermediate host as a means of classification, and tends to discount the value of this test. He points out (p. 260) that the trypanosomes and trypanoplasms of fishes and batrachians carried by leeches

all develop in the same manner in the intermediate host, and remarks (l. 10 from the bottom): "Ce caractère tiré de l'évolution perd donc ici, quand il y a similitude, une partie de sa valeur, et à mon avis c'est surtout la réceptivité du vertébré à l'infection naturelle par les hôtes vecteurs qui constitue le critérium pratique de l'espèce que nos moyens d'investigation, encore bien imparfaits, ne nous permettent pas de mieux définir en l'absence de cette épreuve biologique."

Surely, on the evidence adduced, this is rather a sweeping verdict. Because the "invertebrate-host test" is valueless in diagnosing the trypanosomes of fishes and amphibians, it does not follow that it is equally so for the mammalian trypanosomes and their tsetse intermediaries.

In the case of the mammalian trypanosomes this test enables us to divide the parasites into three groups, and this grouping is supported to a remarkable extent by morphological evidence which is, after all, the essential basis of zoological classification.

Lloyd and Johnstone's recent work has extended the value of this test by shewing that closely allied species exhibit in the fly definite morphological differences (Lloyd, 1924).

As long as a trypanosome-strain is transmissible by its tsetse intermediary the parasite behaves in the tsetse in a constant manner, whether in nature or under laboratory conditions.

When the power of cyclical transmission by tsetse is lost, we cannot, of course, rely on this test. But in such a case the failure to develop in the fly possesses considerable significance, when weighed in conjunction with morphological and biological evidence.

The evidence brought forward by Brumpt in support of Conclusions 2 and 3 seems to me equally to justify the conclusion that *T. brucei* and *T. rhodesiense* are different strains of the same species.

Conclusion 4. "Il me semble difficile d'admettre l'existence de transformations biologiques rapides des trypanosomes s'effectuant sous nos yeux, en Afrique, depuis quelques années."

This is manifestly a statement of personal opinion and not a logical inference from accepted facts, and such biological transformations as were postulated in my argument have actually already been witnessed, in the course of a few years, in the laboratory.

Conclusion 5. "La transmission mécanique des trypanosomes parasites de l'homme en Afrique ne permet pas d'expliquer la gravité de certaines épidemies, gravité qui dépend d'une part, comme celle de maladies non transmises par des hôtes intermédiaires, de certains facteurs qui constituaient pour les anciens auteurs le 'génie épidémique,' facteurs que nous sommes encore incapables de déterminer actuellement et, d'autre part, de l'absence d'immunité des populations neuves soumises à la contagion."

I submit that direct transmission *does* afford an explanation—not necessarily the correct one—of the gravity of certain epidemics. At any rate, this explanation serves as a useful working hypothesis—a claim that can hardly be made for the "epidemic genius" of the old writers.

Speaking of direct transmission as an explanation of the gravity of Sleeping Sickness in certain regions, Brumpt writes (p. 267, l. 31): "Je crois tout à fait inutile d'utiliser cette hypothèse de la transmission mécanique pour expliquer la gravité de la maladie du sommeil dans certaines régions, d'abord parce qu'il n'y a aucune raison d'admettre que le *Trypanosoma gambiense* ne se transmet pas partout par les deux procédés mécanique et cyclique et parce que, d'autre part, il est bien établi que suivant leur pays d'origine, les trypanosomes d'une espèce déterminée peuvent avoir une virulence initiale, c'est à dire à leur première inoculation à un animal sensible des plus variables." I agree that the introduction of virulent strains may be of great importance in the study of the epidemiology of human trypanosomiasis, and that superinfection is doubtless a complication of this exceedingly complex problem. But I do not see that these admissions need divert our attention from mechanical transmission as a factor that may influence the virulence and distribution of human trypanosomes.

At the present juncture we cannot afford to ignore anything that can possibly affect the distribution of the causative parasite, and to oust one unproved theory by another does not advance our knowledge.

Whether direct transmission of *T. brucei* ever occurs in nature, as Brumpt suggests (p. 268, l. 11), in mammals other than man, I do not know. Trypanosomes are, as a rule, rare in the blood of game infected with this organism. In any case, the phenomenon would have no direct bearing on the infection of man by *T. brucei*. Increased virulence, *per se*, does not necessarily carry with it the ability to invade a new species of host animal (in this case, man).

Professor Brumpt says (p. 268, l. 16): "il est difficile de concevoir des lignées pures dérivant exclusivement de passages par le mode mécanique."

In the case of the *T. rhodesiense* type of trypanosome, we are not yet justified in assuming that man is invariably susceptible to infection by flies carrying cyclical infections derived from man—*an assumption frequently made, but one that at the present time has still to be proved.* Direct transmission may thus be the chief, if not the only way by which the *rhodesiense* type of trypanosome can reach new human hosts; and if this is so pure strains may well exist—*in man.*

In the case of *T. gambiense*, mixed infections of man by several strains will be of common occurrence, but I cannot see that this fact invalidates the importance of direct transmission in the spread of human trypanosomes. On the one hand, it is possible that virulent direct-transmission strains arise under natural conditions, just as they do in the course of laboratory manipulations. But apart from this possibility, any factor (including super-

infection with other strains, virulent or avirulent) which tends to increase the severity of the disease in the human host will, by increasing the number of trypanosomes in the peripheral blood, favour the operation of direct transmission and lead to the passage of this virulent strain, be it mono- or polyvalent, through the community.

Conclusion 6. "Il reste encore beaucoup d'études à faire en ce qui concerne l'épidémiologie de la maladie de sommeil à *Trypanosoma rhodesiense* et à *Trypanosoma gambiense*. Il serait intéressant de répéter sur ces germes les expériences sur les variations géographiques de virulence et sur les surinfections que nous avons effectuées en nous adressant au *Trypanosoma inopinatum* et à la sangsue *Helobdella algira* qui est son vecteur naturel."

Professor Brumpt's experiments on the transmission of virulent and avirulent strains of *T. inopinatum* by leeches are convincing and of great interest. As he remarks, it remains to be seen whether similar results will be obtained with the mammalian trypanosomes. It is well known that a tsetse fly may be cyclically infected with more than one species of trypanosome at one and the same time; and it is, of course, possible that variations of virulence may sometimes be sufficiently deep-rooted to survive cyclical passage through the tsetse. In this connection we have also to bear in mind the possible effect on a mammal, already adjusted to an avirulent strain of a trypanosome, of the imposition of a second avirulent strain of the same or a different species.

At Mpumu, Fraser and I found that goats, naturally fairly tolerant of the polymorphic organism from the lake-shore wild fly, succumbed rapidly, with acute nervous symptoms, when superinfected with *T. uniforme*, a species which, in pure infection, appeared to do them no harm.

Brumpt's results with two strains of *T. inopinatum*, one virulent and the other avirulent, suggest an interesting analogy to *T. brucei*. His virulent strain was generally fatal to red frogs, but with the avirulent strain it was very difficult to infect these animals (p. 269, l. 5). He mentions, indeed, one strain which was only infective to the frog when inoculated direct; leeches cyclically infected with this strain failed to infect (p. 257). Yet, in spite of this biological evidence of duality of species, Brumpt satisfied himself by cross-immunity experiments that both were strains of *T. inopinatum*.

With *T. rhodesiense* and *T. brucei* cross-immunity tests have not given such decisive results, and biological evidence alone has turned the scale in the other direction.

As Professor Brumpt says, much remains to be elucidated, and his paper is stimulating both to discussion and investigation. Every reasonable theory deserves consideration, and must be examined carefully in the light of practical experience.

The affinities of *T. brucei*, *T. gambiense* and *T. rhodesiense* form something more than a fascinating proto-zoological study. A complete understanding

of these three parasites is of vital importance to the development of Africa; it will reveal man's full liability to the trypanosome group; and it will render possible, at long last, an effective and co-ordinated policy of control throughout the whole Continent.

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ON THE SPECIES OF *ISOSPORA* PARASITIC IN MAN.

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Some two years ago a proposal was put forward by Wenyon (1923) to change the name of one of the well-known coccidial parasites of man—the parasite which, in my revision of the group (1919), I called *Isospora hominis* (Rivolta). For various reasons Wenyon concluded that there must really be two species of *Isospora* in man—not one, as I had assumed—and he proposed to transfer my amended name *I. hominis* to another organism, whose existence he deduced from the literature and from his own observations on the Coccidia of cats and dogs: but as this would leave the species which I had called "*I. hominis*" without a name, he proposed to rename it "*Isospora belli*."

As the very existence of Wenyon's second species was, at the time, a matter of conjecture, it seemed to me idle to argue about its nomenclature. But the question has recently assumed a new complexion; for Reichenow (1925) now claims to have found the parasite postulated by Wenyon, whose view would thus appear to have been verified. Consequently, it now seems to me necessary to examine Wenyon's hypothesis—and Reichenow's supposed confirmation—in detail. Everybody will agree that the name of a well-known human parasite ought not to be altered unless alteration be imperative, for the confusion which inevitably results from the transference and changing of such names is notorious[1]. I propose to discuss this subject, therefore, with all possible brevity, in the following pages.

Wenyon's paper (1923) deals primarily with the Coccidia of cats and dogs, and not with those of man. With his observations on the parasites of Carnivora[2] I am not here concerned, save in so far as they afford a basis for his discussion of the *Isospora* of man. Briefly, his conclusion concerning the *Isosporae* found in cats and dogs is that there are, in these hosts, three different species of the genus—"One of these has an oocyst about 12–15 microns in length, another an oocyst about 25–30 microns[3] in length, and a third an

[1] I note that at least one writer (Pons, 1925) has already adopted Wenyon's new name: but it is evident, from his own admission and the abundant bibliographic and historic errors in his paper, that he is not himself in a position to form an independent opinion on the question of nomenclature.

[2] I may remark that I have a fairly extensive personal knowledge of these organisms—extending over many years, and including observations (still in progress) on nearly 200 cats.

[3] I quote Wenyon's own words: but he himself states elsewhere (p. 260) that these oocysts, "as seen in English dogs," "vary in length from 20 to 24 microns"—a very considerable discrepancy. Nevertheless, he admonishes us to bear in mind the figures given above when reading the literature.

oocyst about 40–45 microns in length" (*op. cit.* p. 232). The first he assigns to *I. bigemina* Stiles, 1891[1]; the second to *I. rivolta* Grassi, 1879[2]; while for the third he proposes the new name *I. felis*. He states that *I. bigemina*, in its habitat, is "limited entirely to the sub-epithelial tissues of the villi, especially near their distal ends" (p. 258); whereas *I. felis* "is limited to the epithelial cells. In no case has it been seen in the sub-epithelial tissues" (p. 253). Concerning the habitat of *I. rivolta* he states (p. 269) that it is "parasitic in the epithelium covering the villi"; though earlier (p. 260) he mentions that he has only studied it "in the oocyst stage as found in the faeces of three dogs"—from which it may be inferred that he has not himself ascertained its exact situation in the tissues.

Wenyon reaches the foregoing conclusions partly as a result of his own observations, though he relies largely, also, upon the previously recorded findings of others. After discussing the measurements of oocysts given by earlier workers, he summarizes them in a table (*op. cit.* Table I, p. 242), from which, he says, "it will readily be seen that the oocysts described fall into three groups" (presumably those noted in the preceding paragraph). But here are the figures—as he gives them, but rearranged—for the lengths of the oocysts recorded by others[3]:

Observer	Length (μ)
Rivolta (dog and cat)	12–16
Stiles (dog)	13·6–15·9
Hall and Wigdor (dog)	20
Reichenow (dog)	21–24
Wasielewski (cat)	22–25
Wasielewski (dog)	25
Grassi (cat)	27–30·8
Wasielewski (cat)	35–40
Hall and Wigdor (dog)	36–40
Swellengrebel (cat)	39–47
Marotel (cat)	45–48

I leave it to others to judge how readily it can be seen that these measurements fall into the three groups 12–15μ, 25–30μ, 40–45μ. It is mathematically certain, in any case, that such figures afford no proof of the existence of three

[1] Unfortunately dated by Wenyon—by an evident misprint—1901 (*op. cit.* p. 257).

[2] I proposed, in 1919, to amend this name to *I. rivoltae*, since the form in which Grassi proposed it ("*Coccidium Rivolta*") is irregular. According to Wenyon (p. 245), "There seems, however, to be no real reason why the name should be changed at all, and to keep it in the form proposed by Grassi is in accordance with the Rules of Nomenclature." I do not know which of the Rules Wenyon relies on: but I may point out that Art. 19 of the Code not only justifies the correction of errors in orthography, but even makes it incumbent upon a reviser to make such corrections. In 1919 I named one of the Coccidia of man *Eimeria wenyoni*. I wonder whether Wenyon would have seen "no real reason" to change the name if I had called this parasite "Eimeria Wenyon" instead?

[3] I exclude the measurements recorded by Railliet and Lucet, for they refer not to the oocysts but to the *sporocysts*. I have already pointed this out (1919, p. 158), and Reichenow (1925, p. 177) has duly appreciated it: but Wenyon repeatedly assumes (*e.g.* pp. 239, 242)—and wrongly—that Railliet and Lucet's figures relate to oocysts.

distinct species—common to cats and dogs, and having the dimensions postulated: and it is certainly not logically legitimate to assume, as Wenyon apparently does (p. 243), that measurements such as Reichenow's (21–24μ), and those of Hall and Wigdor (20μ), fall within a group of oocysts measuring 25–30μ in length.

It would not be unreasonable to require anyone who proposed to demonstrate the existence of three such species of *Isospora*, in cats and dogs, to give a series of accurate measurements of oocysts in support of his contention. But Wenyon, unfortunately, gives none; and this makes it very difficult for others to recognize the limits of his species. For example, if I find—as I often do in kittens—oocysts having various lengths from 30μ to 40μ, am I to refer these to "*I. rivolta*" (25–30μ) or to "*I. felis*" (40–45μ)? Surely, if species are to be discriminated by dimensions, it is incumbent on the species-maker to supply us with adequate statistics for working purposes.

It is remarkable, moreover, that Wenyon himself, in the very paper under discussion, describes a new species of *Eimeria* (*E. canis*), from the dog, characterized by the "great range in size" of its oocysts. In this "species," according to him, the oocyst "varies in length from 18 to 45 microns," while "the sporocysts show the same proportional variation in dimensions as do the oocysts" (p. 261). The range in size is thus closely similar to that found in the *Isosporae* of dogs and cats. No statistical evidence is advanced to show that the measurements of this *Eimeria* form a continuous series and those of *Isospora* a discontinuous: but Wenyon asks us to believe that the same sort of figures indicate the existence of one species of the former genus but three species of the latter. I must leave it to him to explain the mathematics of this problem, and to disclose his method of analysing his measurements. From what he has published it is impossible for others to ascertain any statistical basis for his apparently discrepant conclusions.

But I suppose that Wenyon would agree with Reichenow that the chief difference between his species of *Isospora* consists "not in the shape and dimensions of their oocysts, but in their mode of development. For whereas the stages of *I. rivolta* and *I. felis* are situate in the epithelium of the small intestine, and discharge their oocysts with the faeces in an unripe state, the development of *I. bigemina* takes place in the *subepithelial* tissue, where the sporogony is completed: so that the oocysts of the latter species can appear in the freshly discharged faeces in the ripe condition[1]." Wenyon states that "*I. bigemina*" completes its sporogonic development in the subepithelial tissues, and he gives a figure (Fig. 2, p. 259) showing small, fully formed oocysts and spores in this site. Consequently, it must be concluded that the specific characters of his "*I. bigemina*" are not only (1) the small size of its oocysts (12–15μ[2] in length), but also (2) the circumstance that they are

[1] Reichenow (1925), p. 173—translated.

[2] Wenyon himself gives these figures: but from what source the figure 15 is derived, I have been unable to discover.

discharged with their spores fully developed—not unsegmented, as in other species.

As regards this second character, however, we have contradictory testimony from Wenyon himself. For he tells us (p. 244) that Sheather has seen the small oocysts (*I. bigemina* of Wenyon) in the faeces of a dog[1], and that they "measured about 12 microns in longest diameter, and *like those of intermediate size* [*I. rivolta* of Wenyon] *were in the undeveloped condition*[2]. They proceeded to development when kept outside the body." How such observations are reconcilable with a belief in a small species of *Isospora* which completes its sporogony in the subepithelial tissues, is not explained: and to me Sheather's observations appear obviously to contradict, not confirm, Wenyon's own statements.

Is it not possible that the small and completely developed oocysts, observed by Wenyon in the subepithelial tissues, merely represent parasites—normally living in the epithelium—which have strayed into the deeper layers of the gut wall? (Analogies for such a supposition can easily be cited.) Their small size and complete development could be explained by their abnormally close confinement in the tissues and their inability to escape. On this hypothesis, such subepithelial oocysts would be expected to occur only when the epithelium also was parasitized: for if subepithelial oocysts occurred *alone*, this interpretation would hardly be warranted. Yet Wenyon does not describe a single case in which he has found subepithelial oocysts *only*. He describes only one cat showing these forms, and its ileal epithelium was simultaneously infected with the ordinary larger forms (referred by him to *I. felis*). But concerning this observation he makes the following remarkable statement: "The question of a possible relationship between this parasite ["*I. bigemina*"] and the very much larger *Isospora felis* which develops only in the epithelium has been considered. It might be urged that if *Isospora felis* developed in the subepithelial tissues it might take on the character of the smaller form. The latter, however, has only been seen in one animal, while many infected with *Isospora felis* alone have been studied. It seems clear, therefore, that the small form is a distinct species" (*op. cit.* p. 260). I confess that, to me, this conclusion seems neither clear nor logical. If Wenyon had found a single cat in which the subepithelial parasites were present *alone*—with none in the epithelial layer—I could admit that they might belong to a different species: but when he concludes that the subepithelial parasites are a distinct species because he has found them in a single kitten in whose epithelium similar but larger parasites were also present, I am completely baffled by his reasoning. His conclusion is diametrically opposed to that which I should draw from his observations.

There is another point in Wenyon's paper to which I must refer, since it

[1] I have seen similar small undeveloped oocysts in the faeces of kittens, and have watched their development outside the body.

[2] The italics are mine.

may be of considerable importance in this connexion. He says (p. 257) that the oocyst of *I. felis* "does not become a resistant structure till the macrogametocyte has left the cell for the lumen of the intestine. In no case was there any indication that the further development of the contents took place, either in the cells or in the lumen of the intestine." This statement is completely at variance with my own experience, for I have repeatedly observed large resistant thick-walled oocysts ("*I. felis*"), with their contents already contracted into a spherical mass, inside the villous epithelium of kittens only just killed. I am convinced that they normally reach this stage of development while still in the intestinal wall: and how Wenyon can have failed to see them, if he has ever examined scrapings of the fresh intestinal mucous membrane of half-a-dozen kittens, I cannot understand.

Oocysts with thick walls, and their contents contracted into a sphere, can develop further and complete their sporogony under suitable conditions. Their walls are impervious to most cytological reagents, and in some fixatives they will even undergo further development[1]. They will certainly develop at times in alcohol; and I have once directly observed, under the microscope, complete sporogony in the oocysts of "*I. felis*" immersed in Carnoy's fluid (alcohol-chloroform-acetic acid)—one of the most penetrating fixatives known. It is well known that the older workers used alcohol extensively as a fixative: and I have always supposed that, when they described "paired psorosperms" in the tissues, they had observed oocysts which had continued to develop in their fixing fluids. I still think that this is the most plausible explanation of their observations.

It is quite true that the *Isosporae* of cats and dogs do not usually complete their sporogony in the living bodies of their hosts: but if fully developed oocysts are found in preserved tissues, it is not legitimate to conclude—without further evidence—that sporogony occurred while the host was still alive. When Wenyon says, immediately after the passage last cited, "It follows, therefore, that whenever observers have described the occurrence of paired bodies in the intestine wall they cannot have been referring to the oocysts of *I. felis*," I do not agree with him. His statements about "*I. bigemina*" (p. 257), and his Figure (p. 259), prove nothing: for it is clear that in the particular case noted—the only one he appears to have observed—the large epithelial oocysts depicted ("*I. felis*") had not reached their final stage of development in the cat studied—the stage at which they become impermeable, and capable of further development (even in certain fixatives) outside the body of their host or inside it after its death.

There are many other details in Wenyon's descriptions, and in his interpretations of the works of others, with which I am also unable to agree; but I need not discuss these here. I wish merely to point out that he has presented

[1] In certain fixatives however—of which strong formalin is an example—they will not develop, although this reagent will not readily penetrate the walls and fix the contents. Unfortunately Wenyon says nothing about the methods of fixation which he used.

no conclusive evidence to prove that there is a distinct species of *Isospora* ("*I. bigemina*") occurring in both cats and dogs, and distinguishable by the small size (12–15μ) of its oocysts and by the circumstance that it normally completes its sporogony—in the living host—in the subepithelial tissues of the villi, from which it escapes in the faeces in a fully differentiated condition (*i.e.* as an oocyst containing ripe spores with fully formed sporozoites). Indeed, it is not apparent from Wenyon's paper that he himself (or anybody else) has ever once observed a single such oocyst in the freshly discharged faeces of any cat or dog: while Sheather's observations, which he quotes in support of his hypothesis, appear to be contradictory rather than confirmatory.

Wenyon, believing he has proved—as he certainly has not in his paper—that cats and dogs harbour a small species of *Isospora* which completes its sporogony in the subepithelial tissue of the villi, proceeds to argue analogically that a similar parasite must occur in man. He does not, of course, argue that there are two species of *Isospora* in man simply because he finds three species in cats and dogs—for this would be absurd: but having found, as he believes, a small and specifically distinct subepithelial *Isospora* in a cat, he looks for—and finds—evidence in the literature for the existence of a similar organism in man. I have tried to show that he has by no means proved his point for the Carnivora, and I shall now try to show that still less has he proved it for man.

The first known case of *Isospora* infection in man is that discovered by Kjellberg and recorded by Virchow (1860). Wenyon quotes (pp. 263–4) a relevant passage in Virchow, though not with literal accuracy, and concludes from it that Kjellberg's parasites belonged to a small species which inhabited the subepithelial tissue of the villi and not the epithelium: because Virchow says that they were just like those which he had himself seen "*im Innern der Darmzotten*" in a dog[1], and refers to them as "*relativ kleine.*"

Now Wenyon assumes, as does Reichenow also, that when Virchow says the coccidia were present *in the interior of the villi*, he "recognised" that they "occurred in the tissues [by which Wenyon apparently means the *subepithelial* tissues] of the villi and not in the epithelium" (*op. cit.* p. 266). But this is surely unwarranted. Virchow says nothing about epithelial and subepithelial tissues. He merely notes that the parasites were present "inside the villi" (*i.e.* not outside or on their surface); and as he makes no other mention of their precise habitat[2] there is no real justification for concluding that he saw the parasites in the subepithelial connective tissue and not in the epithelium. Parasites wholly inclosed in the villous epithelium are "inside the villi"—not outside[3]. There is thus nothing in Virchow's words to prove that Kjell-

[1] Only one—not "in dogs," as Wenyon states (p. 263).

[2] He does, however, say of the human parasite that it occurred "*gegen die Spitze der Darmzotten*": and as the tip of a villus is composed of epithelium, one might conclude from this that the parasites were in the epithelial layer.

[3] It should be noted also that when the villi are examined in fresh scrapings of the mucosa, the oocysts lying in the epithelium can easily be fancied to lie *inside* the villi (*i.e.* in the sub-

berg's coccidia inhabited the subepithelial connective tissue rather than the epithelium of the villi.

Many writers have described the *Isosporae* of carnivores as living "in the villi": but I doubt whether anyone before Wenyon has understood this to imply that their parasites did not inhabit the epithelium. Virchow's words have long been familiar to me and I have long been acquainted with the coccidia in cats and dogs; but it never occurred to me, before reading Wenyon's paper, that Virchow's statements were irreconcilable with my own observations. Until Wenyon found—in preserved material—his small, fully differentiated oocysts in the subepithelial tissue of a kitten, I think even he would have regarded it as hardly justifiable to conclude from Virchow's words that Kjellberg's human parasites differed from all other known intestinal species of *Isospora* in that they inhabited the connective tissue and not the epithelium. Such an inference is still, in any case, unsupported by direct testimony.

Because Virchow says that Kjellberg's coccidia were "relatively small," Wenyon apparently assumes that they must have belonged to a *small species* of the genus *Isospora*. But this inference again is quite unwarranted. It is certain that by "relatively small" Virchow cannot have meant "small in relation to other species of the genus"—for as everyone knows the genus had then been neither proposed nor defined. Exactly what he meant I do not profess to know; but it seems natural to take his words to mean that the parasites were *small in relation to the size of the villi* in which he saw them; and if this obvious interpretation be correct, there is nothing here to indicate that Kjellberg's parasites belonged to an *Isospora* distinguished from other species of the genus—then unfounded—by its diminutive size.

Wenyon, after discussing Virchow's words, says (p. 266): "The only possible conclusion which can be drawn legitimately from these precise statements is that Virchow actually meant what he said and was observing in man a small *Isospora* like *Isospora bigemina* of dogs and cats." This is so much like what I had myself previously said about these observations (1919, p. 152 *et alibi*) that it might appear that Wenyon and I are in complete agreement on this point. But we are not: and the difference lies in Wenyon's conception of "*Isospora bigemina*." When he says "a small *Isospora* like *I. bigemina*," he really assumes that Virchow meant very much more than he said. He assumes that Virchow meant "a small *species* of *Isospora* (with an oocyst 12–15μ in length), whose oocysts are situate in the subepithelial layer—never in the epithelium—and one which always completes its sporogony in this site in the living host." Such implications appear to me devoid of all foundation.

So convinced is Wenyon that Kjellberg's *Isospora* belonged to a much smaller species than the now well-known form from man, that he has even

epithelial layer). Careful focussing demonstrates that they are usually in the superficial epithelium, though their optical position in the middle of the villus often at first sight appears to indicate that they are more deeply situated.

published a picture of it, drawn to scale, despite the fact that neither he nor any other man—if we exclude Kjellberg and Virchow, who have recorded no measurements—has ever seen it. It should be emphasized that this drawing (*op. cit.* Text-fig. 1, 1, p. 233) is, so far as any known human parasite is concerned, entirely imaginative. It depicts an oval oocyst measuring approximately 13μ in length, and containing two spores, each about 7μ in longest diameter. Although confidently described as occurring "in the deeper layers of the villi... of man," I can say with equal confidence that, to my knowledge, no such organism has ever been recorded from man, and no example of it is known to exist.

The only species of *Isospora* known to occur in man is the now familiar form which I have called *I. hominis* (Rivolta). I shall discuss its nomenclature presently, but I must note here that nobody yet knows its precise habitat in the human body. This parasite is known with certainty only from its oocysts, which pass out with the faeces. It probably lives in the villi of the small intestine, but whether in the epithelial or subepithelial layer has still to be determined[1]. Consequently, even if it could be proved—and I believe it cannot be—that Kjellberg's parasites inhabited the subepithelial layer and not the epithelium, this, in itself, would be no proof, in our present state of knowledge, that they did *not* belong to the well-known species. Wenyon's conviction that man also harbours a smaller subepithelial form is not founded on any actual observations, while his assumption that *I. hominis* (Rivolta) can live in the epithelium *only* is obviously nothing but a guess.

In our present state of knowledge—or rather ignorance—we may, I think, fairly state the position as follows: We know that man harbours one species of *Isospora*—the one I call *I. hominis* (Rivolta)—but we do not know exactly where it lives in the tissues. Wenyon assumes that it inhabits the epithelium, never the subepithelial layers, of the villi of the small intestine: but he has never seen it there, and advances no direct evidence for this inference. But, in addition, he postulates a second and smaller species with oocysts only 13μ or so in length, which neither he nor any other worker has yet seen and described, and he says that this lives exclusively in the subepithelial tissues of the villi, where it completes its sporogony. (According to his figure, the spores—passed in a fully developed state in the faeces—measure 7–7·5μ in length.) Wenyon infers all this from the statements of Virchow—which can be otherwise interpreted—and from a supposed analogy existing between the coccidia of man and those of carnivores (cats and dogs). Such analogy is not, at present, justified; since we cannot infer anything regarding the parasites of one animal from those of others belonging to a different Order, until we have studied them. Moreover, the supposed facts concerning the species of *Isospora* in cats and dogs, on which the analogy is based, have by no means

[1] In an earlier paper, published in 1915, Wenyon stated that "the development of the coccidium takes place in the epithelial cells of the gut": but so far as I am aware this statement was not based upon any actual observations.

been established. Consequently, it is premature to draw conclusions about the parasites of man from the inconclusive observations made on those of cats, dogs, or any other carnivores—even though they be coupled with a variety of questionable literary data.

Let us now turn to Reichenow's (1925) confirmation of Wenyon's hypothesis. "An accidental finding in a stool" has "put him in a position," he says, "to confirm the correctness of Wenyon's assumption of the occurrence of two species of *Isospora* in man" (p. 174). He has rediscovered "the cyst" of the small species of *Isospora* postulated by Wenyon, "65 years after the discovery of this parasite," and "for the first time" (p. 176). But when we examine Reichenow's facts, apart from his speculations, we find that all he has found is a couple of coccidial spores "16μ long and 10·5μ broad; they contained, besides the four sporozoites, scanty residual substance" (p. 175). These spores were found in "the fresh liquid stool" of a sailor suffering from amoebic dysentery, and repeated search for further specimens was unsuccessful (p. 175). They lay superimposed in "a pretty dense mass of faeces," while the oocyst assumed to surround them was not seen (p. 175), and was therefore not measured.

In other words, Reichenow has once observed, in a sample of fresh human faeces, two spores whose dimensions and structure[1] agree sufficiently closely with those of the well-known organism *Isospora hominis* (Rivolta) for it to be clearly justifiable to refer them to this species. The only objection to doing so is that the spores of this species usually complete their development outside the body, while Reichenow's pair appear to have been passed in a fully developed condition. Yet, in his estimation, this observation supports Wenyon's belief in the existence of a small species of *Isospora* in man—a species which completes its sporogony in the subepithelial tissue of the villi. Reichenow offers no evidence at all to show that his spores underwent their development in this situation: and when he asks us to believe that these spores, measuring 16μ in length (like those of *I. hominis*), support Wenyon's belief in a species with spores measuring 7μ, it becomes difficult to take him seriously. If Reichenow's isolated observation has any import at all, it merely indicates that the oocysts of *I. hominis* (Rivolta) may very exceptionally[2] leave the body in a fully developed state—instead of developing outside, as they usually do. Evidence in favour of Wenyon's hypothetical small subepithelial species there is here none whatever: and it thus seems impossible to admit that Reichenow has either verified Wenyon's guess or established his own claim to be the first to rediscover the parasites originally seen by Kjellberg.

At present, therefore, there seems to be no direct evidence to indicate—

[1] The amount of residue present in the spores is of no diagnostic importance, for in *Isospora*—as in other coccidia—it decreases with the age of the spores. For example, in *Aggregata* there is at first a large residue, which is reduced later to a few minute granules (Dobell, 1925).

[2] One specimen has been recorded (by Reichenow) out of many hundreds (seen by others).

still less to prove—that more than one species of *Isospora* parasitizes man. There *may*, of course, be more than one; but as yet only one species appears to have been described.

Even before the publication of Reichenow's paper, Wenyon had proposed to transfer the name *I. hominis* from the well-known and described species to his hypothetical smaller one; and as this would deprive the known organism of its name, he further proposed to rename this species "*I. belli*"—which he considers "an appropriate name for the *Isospora* of man which figured so largely during investigations on the intestinal parasites of man conducted during the war" (*op. cit.* p. 269).

I have already (1919) given my own views on the nomenclature of this organism, and I have not changed them; so I need not reiterate what I have said. I need only note here certain points wherein Wenyon's interpretations differ from mine. The chief of these are the following:

(1) Wenyon states that Kjellberg's parasites were first named *Isospora hominis* by Railliet and Lucet (1891), and that this name, therefore, belongs to this species—but not to the known and described species. He says "that to submerge this form [*i.e.* Kjellberg's] by applying the name to a much larger and evidently distinct species which is perhaps more easily detected, is not only contrary to scientific procedure, but is unfair to its discoverer and misleading to future investigators" (*op. cit.* p. 269). To this I would reply (*a*) that there is as yet no good evidence to prove that Kjellberg's *Isospora* and the "much larger and evidently distinct species" are not identical: (*b*) that it is also "contrary to scientific procedure" to draw far-reaching conclusions from insufficient premisses: and (*c*) that it is not obvious how the proposed change avoids being "unfair to its discoverer" or "misleading to future investigators." The discoverer referred to is presumably Kjellberg: yet in what sense it is "fairer" to him to call his parasite "*I. hominis* Railliet et Lucet," rather than "*I. hominis* Rivolta," we are not told; nor is it made clear how "future investigators" are likely to be less misled by the former than by the latter appellation. I cannot help thinking that here again Wenyon has been premature in accusing me—albeit indirectly—of unscientific procedure, of unfairness to one of my predecessors, and of misleading future workers. I plead "not guilty" to all these charges.

As a matter of fact, the specific name *hominis* was first given to a coccidium of man by Rivolta (1878), not by Railliet and Lucet (1891): and the name was given not to Kjellberg's parasites but to those recorded by Eimer (1870)[1]. Wenyon is aware of this, but he surmounts the difficulty by saying that it "is far from clear" whether Eimer's parasites "were coccidia at all." "Rivolta's name *Cytospermium hominis* was given," he says, "to certain bodies seen by Eimer which may or may not be coccidia" (*op. cit.* p. 264).

[1] When Reichenow (1925, p. 174) avers that "the specific designation *I. hominis* belongs to the parasites discovered by Kjellberg," he makes an equivocal statement. In one sense it is true, in another false.

He therefore rejects Eimer's observations *in toto* and regards the name bestowed upon his parasites as *nomen nudum*.

But is it allowable to dismiss Eimer's record in this summary fashion? As every protozoologist knows, Eimer is one of the classical writers on the Coccidia; and consequently, when he says that he found coccidia in two human cadavers, we cannot wholly disregard his words. The probability is that he was neither mistaken nor untruthful. He knew what he was talking about, and, like Virchow, doubtless "meant what he said." At all events, as an authority on the Coccidia Eimer is at least as good as Virchow. For certain reasons (which I do not know) Rivolta referred Eimer's parasites to his own genus *Cytospermium*—the genus in which he also placed what was certainly an *Isospora* of the dog. He did *not* refer them to his genus *Psorospermium*—which was equivalent to the modern *Eimeria*. There is thus some justification for regarding Rivolta's name *hominis* as appertaining to an *Isospora* of man. I proposed (1919), therefore, to give both Eimer and Rivolta the benefit of the doubt, and to apply the name *Isospora hominis* to the commonest and only known species of the genus found in man. I still regard this as the most rational procedure. In dealing with the older writers, as with most moderns, we must constantly make allowances for their restricted knowledge and resources. If we take the first full and absolutely correct description of any species as the only one valid, we can easily upset the accepted nomenclature of every known protozoon. First accounts are invariably, and almost necessarily, incomplete and faulty.

(2) It seems to me curious that Wenyon accepts the specific name *hominis* when proposed by Railliet and Lucet, but rejects it when proposed earlier by Rivolta—the name, in both cases, having been given at second hand to parasites described by others. It is to be noted, moreover, that Railliet and Lucet (1891)—whose designation Wenyon accepts—proposed their name in a most irregular manner. They merely remarked that there is "perhaps" a *variety* "*hominis*" of "*Isospora bigemina*" in man, "corresponding to the form observed by Kjellberg." Whether this constitutes a valid proposal of a specific name, according to the Rules of Nomenclature, is debatable: while it is equally debatable whether Kjellberg's parasite differed in any way from the species of *Isospora* for which Wenyon proposes the new name *belli*—the one that I call *I. hominis* (Rivolta).

(3) When Wenyon proposes the curious name "*I. belli*" for the species of *Isospora* which I have already called *I. hominis* (Rivolta), he appears to forget that it is the recognized right of the reviser of a species to split it up, if necessary, and to assign the original collective name to one of the parts. *If* there is more than one species of *Isospora* in man—and this is not yet proved—then I have already assigned the name *hominis* to the very species which Wenyon proposes to rename *belli*. I did not assign it to the organism postulated by Wenyon—of which I knew, and still know, nothing.

If Wenyon maintains that the name *I. hominis* (Rivolta) is invalid, as it

is not founded on any known type specimen, and was proposed for an unidentifiable organism, then one is equally entitled to say the same of the identical designation proposed by Railliet and Lucet. If *Cytospermium hominis* is regarded as *nomen nudum*, then *Isospora bigemina* var. *hominis* Railliet et Lucet may also be nullified on similar grounds. Consequently, the first name used for the well-known and already described species of *Isospora* from man is neither *I. hominis* (Rivolta) nor *I. hominis* Railliet et Lucet, but *I. hominis* Dobell—since I called the parasite by this name in 1919 (*i.e.* four years before Wenyon proposed to call it "*I. belli*"). It is a fine point, perhaps; but whichever way Wenyon argues it, it seems difficult to justify "*I. belli*" as a valid name for a species which has already been named *hominis* at least once and possibly thrice.

From the foregoing considerations, and many others which I have not space to mention, it therefore appears to me legitimate to draw the following

CONCLUSIONS.

(1) There is as yet no good evidence to prove that more than one species of *Isospora* occurs in man.

(2) There are no sound reasons for changing the name of this species from *I. hominis* (Rivolta) Dobell, 1919, to *I. belli* Wenyon, 1923.

(3) And consequently the name *I. belli* Wenyon should, for the present, be regarded as a synonym of *I. hominis* (Rivolta).

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[Exact references to works published prior to 1919 will be found in the first paper cited, and are therefore not included here.]

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REPORT ON A COLLECTION OF PARASITIC NEMATODES, MAINLY FROM EGYPT.

PART IV. TRICHOSTRONGYLIDAE AND STRONGYLIDAE.

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(With 28 Text-figures.)

The present paper is a further instalment of the Reports on the Molteno Institute collection, of which Parts I–III, dealing with the Ascaridae, Heterakidae, Oxyuridae, Camallanidae, etc., were published in this *Journal* by Dr H. A. Baylis in 1923. The history of the collection has been dealt with by that writer, and the following report on the Trichostrongylidae and Strongylidae is presented in as nearly as possible the same form as that of the preceding parts, consisting of a list of determinations of the material, together with notes on the less well-known forms and full descriptions of the new species. As in Parts I–III, the numbers attached to each set of specimens are the serial numbers given to the original tubes at the Molteno Institute.

The collection received in Cambridge contained a number of named specimens as well as the undetermined material; at Dr Baylis' suggestion I have added to my list the names of the few worms belonging to the families dealt with which had already been identified (presumably by the late Dr Looss) in Egypt. The numbers attached to these specimens are indicated by asterisks, to distinguish them from those for which I accept responsibility.

Superfamily **STRONGYLOIDEA.**

Family TRICHOSTRONGYLIDAE.

Genus **Trichostrongylidae** Looss, 1905.

Trichostrongylus probolurus (Railliet, 1896).

557 (part). From sheep. Locality, Cairo.

Trichostrongylus vitrinus Looss, 1905.

557 (part). From sheep. Loc., Cairo.

Genus **Oswaldocruzia** Travasses, 1917.

Oswaldocruzia filiformis (Goeze, 1782).

537 (part). From *Rana temporaria.*

554 „ *Rana* sp.

570 „ *Anguis fragilis.* Loc., Leipzig.

Genus **Haemonchus** Cobb, 1898.

Haemonchus contortus (Rudolphi, 1803).

106*. From *Sus scrofa* (!) Loc., Leipzig.

Genus **Nematodirus** Ransom, 1907.

Nematodirus filicollis (Rudolphi, 1802).

107*. From *Ovis aries*. Loc., Cairo.

Nematodirus abnormalis May, 1920.

557 (part). From sheep. Loc., Cairo.

This interesting species has previously been recorded from the small intestine of sheep and goats in America only (May, 1920).

Genus **Histiostrongylus** Molin, 1861.

The genus *Histiostrongylus* was established by Molin to include a remarkable species, *H. coronatus*, from the small intestine of a bat, *Phyllostoma discolor*, from Brazil. Molin's description and figures of this species are very incomplete and have given rise to some doubt as to the generic characters. No worms possessing the striking peculiarities of *H. coronatus* have been described in recent years, but certain other Trichostrongylids from bats have been provisionally included in the genus (Travassos, 1921) in spite of marked differences from the type species.

Included in the collection from Egypt are a number of specimens from *Taphozous perforatus* which are of great interest, because, although on account of differences in size, relative measurements, etc., they are obviously not specifically identical with the worms described by Molin, they possess all the more salient peculiarities of the type-species and must certainly be included in the same characteristic genus, which it now becomes possible to diagnose accurately.

The following generic diagnosis is based on the characters common to Molin's species and to the form from *Taphozous perforatus* which I propose to name *Histiostrongylus spinosus* sp.n.:

TRICHOSTRONGYLIDAE, with cuticle of head expanded anteriorly to form an annular membrane, the border of which is produced into a series of large, simple or bifurcated, spines directed backwards. Mouth-cavity small, with a circular opening, leading to a relatively short, club-shaped oesophagus. Cuticle longitudinally striated.

Female with vulva behind the middle of the body, with well-developed ovejectors and divergent uteri. Tail short, ending in a slender terminal spike and provided also with a pair of small ventro-lateral processes.

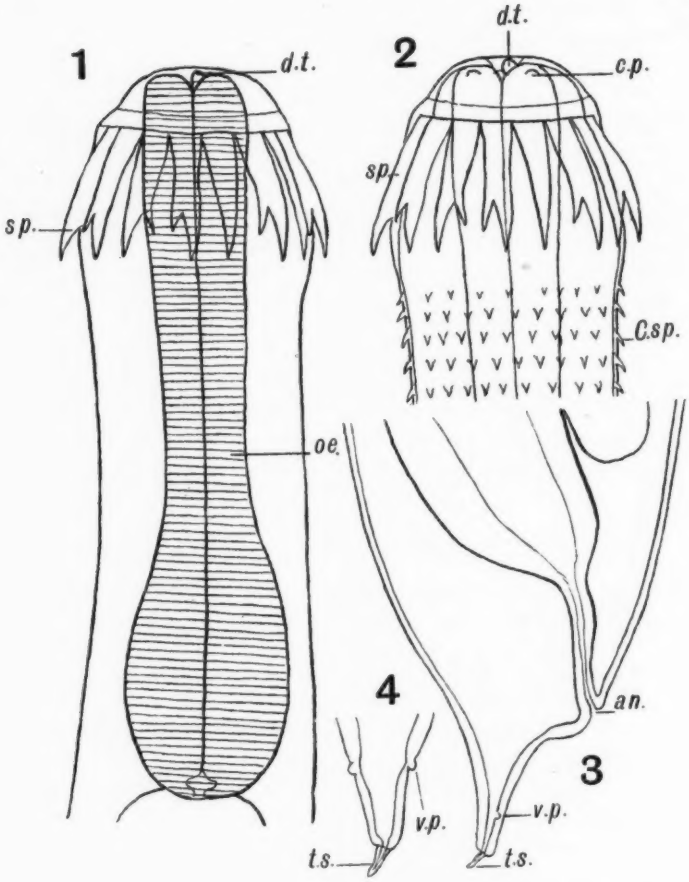
Male with well-developed trilobed bursa, the latter with a small dorsal and large lateral lobes. Ventral rays of bursa larger than the other rays and approximately parallel. Lateral rays originating together, the externo-laterals larger than the others and diverging from them, medio-lateral and

postero-lateral rays with common stem and closely approximated. Externo-dorsal rays short and slender. Dorsal ray with pair of small lateral branches, and bifurcating distally. Spicules equal, long and slender, with slightly expanded terminal membranes. A gubernaculum is present.

Histiostrongylus spinosus sp.n.

555. From *Taphozous perforatus*, intestine.

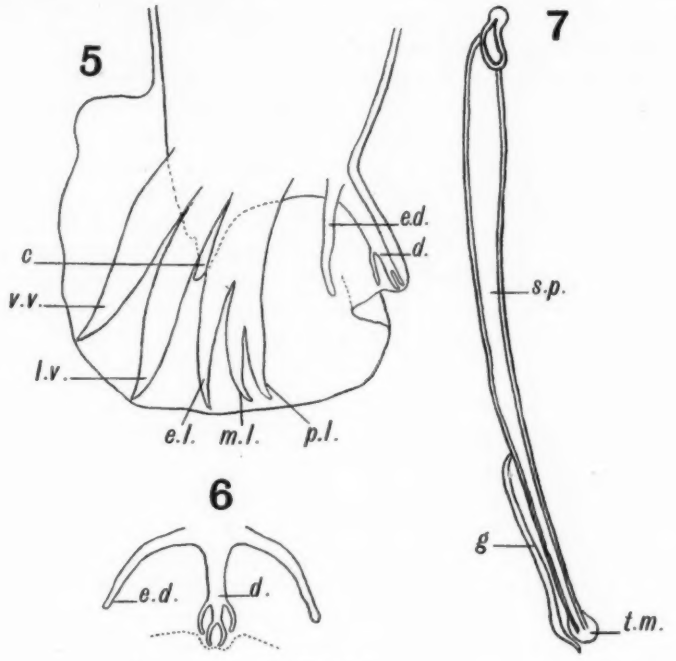
Body cylindrical, slightly attenuated towards the two extremities. Head (Fig. 2) with cuticle slightly inflated, and giving rise anteriorly to an annular



Figs. 1–4.

Histiostrongylus spinosus. Fig. 1. Anterior extremity of male; lateral view. ×250. Fig. 2. Head of male; lateral view ×250. Fig. 3. Posterior extremity of female; lateral view. ×250. Fig. 4. Tip of tail of female. (Lettering explained on p. 100.)

expansion, the border of which is produced into a series of 14–16 large, backwardly directed spines, which may be simple or, more frequently, bifurcated at their extremities. Behind the ring of large cephalic spines the cuticle gives rise to a further, and more numerous, series of small spines arranged in, more or less, parallel rows and extending along the anterior body region to about the level of the termination of the oesophagus, or a little beyond it. Surrounding the small circular mouth-opening are six inconspicuous head-papillae (two lateral and four submedian). The small mouth-cavity is



Figs. 5–7.

Histiostrongylus spinosus. Fig. 5. Male bursa; lateral view. ×250. Fig. 6. Male, dorsal and externo-dorsal rays of bursa; dorsal view. ×250. Fig. 7. Male spicule and gubernaculum; lateral view. ×250. (Lettering explained on p. 100.)

funnel-shaped; its cuticular lining is produced on the dorsal side to form a short, blunt tooth which may project a short way beyond the mouth opening. The oesophagus (Fig. 1) is stout and approximately club-shaped, measuring 0·4 to 0·55 mm. in length.

Males 4·8 to 5·6 mm. in length with a maximum thickness of about 0·18 to 0·2 mm. The bursa has a very small dorsal and two large lateral lobes; the median dorsal ray gives off two slender side branches and is bifurcated at its extremity (Fig. 6); the externo-dorsal rays are slender and short,

terminating some distance from the bursal margin; the narrow postero-lateral and medio-lateral rays (Fig. 5) have a common stem and are almost parallel, the externo-lateral rays originate with them, but are larger and diverge from them; the ventral rays are large and parallel, except at their pointed extremities, the latero-ventrals are a little larger than the ventro-ventrals. There is a well-developed genital cone, the dorsal lip of which is considerably longer than the ventral and terminates in a long, narrow process. The spicules are equal and have a length of 0·37 to 0·4 mm., rather stout proximally, they taper somewhat towards their distal extremities, the membranes of which form slight spathulate enlargements (Fig. 7). The slender gubernaculum measures 0·13 mm. in length.

Females 5·6 to 9 mm. in length with a maximum thickness of 0·22 to 0·35 mm. The anus is 0·12 to 0·13 mm. from the posterior extremity of the body; the conical tail has a truncated apex from which springs a slender terminal spike. A short distance in front of the apex is a pair of small, ventro-laterally situated papillae (Figs. 3 and 4), these I take to correspond to the two little spine-like processes shown by Molin in his figure of *H. coronatus*. The vulva is situated 1·8 to 2·75 mm. from the posterior extremity; the vagina is very short and leads to the two ovejectors, the combined length of which (including the sphincters) is 0·25 to 0·32 mm., the uteri are divergent. The eggs measure 0·12 to 0·13 mm. by 0·07 to 0·08 mm.

Note on *Histiostrongylus paradoxus* Travassos.

Under the name of *Histiostrongylus paradoxus*, Travassos (1921) described a Trichostrongylid obtained from the small intestine of bats belonging to the family Molossidae from Brazil; the generic identification was only meant to be provisional, since it was obvious that these worms lacked certain of the more striking features so characteristic of Molin's type species. From the study of the form just described it becomes clear that Travassos' species can no longer be included in the genus *Histiostrongylus*, it must therefore form the type of a new genus which I propose to call *Anoplostrongylus*. This is to be distinguished from *Histiostrongylus* by the absence of spines from the cuticular expansion of the head-region; by the characteristic caudal extremity of the female, provided with three, backwardly directed, spine-like processes, in addition to the terminal tail-spike; and by the structure of the male spicules which possess barbed distal extremities.

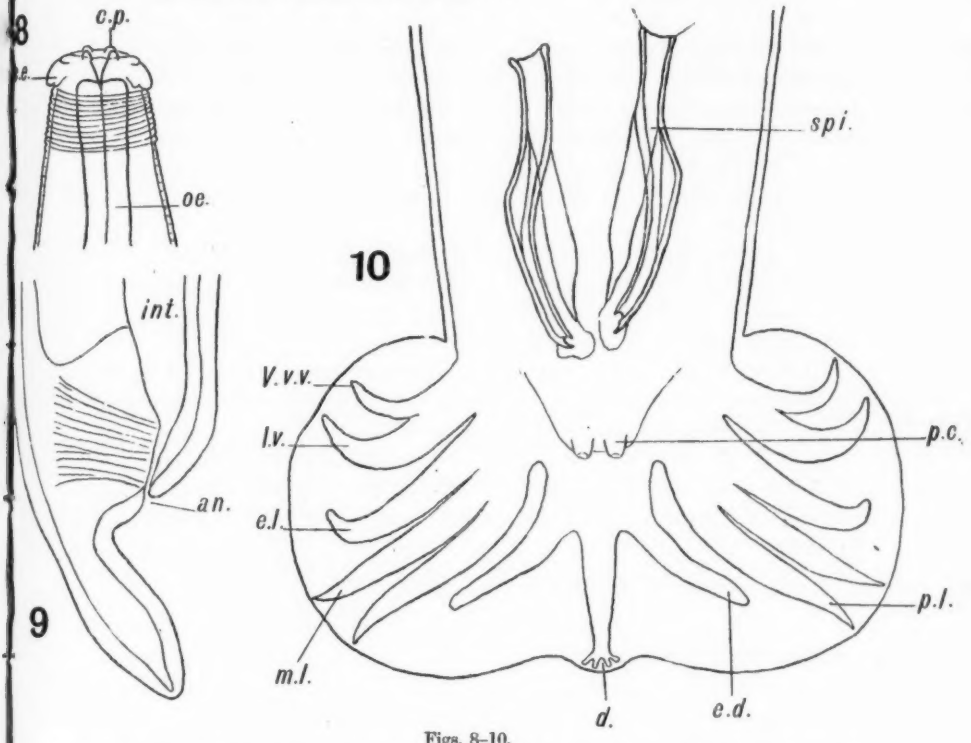
Strongylus tipula van Beneden, 1873 (*Histiostrongylus tipula* Travassos, 1918), obtained from species of *Vespertilio* in Belgium, seems to resemble Travassos' species in the structure both of the head and of the female caudal region; if we ignore the obviously inaccurate figures of the male genitalia given by van Beneden we may place it in the same genus.

Genus **Epomidiostomum** Skrjabin, 1916.

Epomidiostomum querquetulae sp.n.

546. From *Querquetula crecca*, stomach-wall.

This tube contains a number of Trichostrongylid worms which I take to be congeneric with the interesting form described by Skrjabin (1916) from the gizzard-wall of domestic and wild ducks, and named *Epomidiostomum anatinum*. The worms from *Querquetula crecca* differ from the type species in size as well as in a number of anatomical characters, and are described as belonging to a new species, *E. querquetulae*.



Figs. 8–10.

Epomidiostomum querquetulae. Fig. 8. Anterior extremity of male; dorsal view. ×500. Fig. 9. Posterior extremity of female; lateral view. ×250. Fig. 10. Posterior extremity of male; ventral view. ×250. (Lettering explained on p. 100.)

Body elongated, slender and of a yellowish colour, considerably attenuated anteriorly and terminating in a very small head.

Head provided with a pair of laterally situated cuticular expansions (Fig. 8), reflected backwards and, although less developed, obviously corresponding to the "épaulettes" described by Skrjabin in the type-species.

Mouth surrounded by six head-papillae, four submedian and two lateral in position. Mouth cavity funnel-shaped, leading to the elongated, club-shaped oesophagus.

Cuticle provided with conspicuous transverse striations, these are closer together and better marked just behind the head, giving a very characteristic wrinkled appearance to what may be called the neck-region (Fig. 8).

Male 8·8 to 10·5 mm. in length, with a maximum thickness of 0·18 to 0·2 mm. Head only 0·035 mm. in diameter. Oesophagus 1 to 1·05 mm. long.

Bursa trilobed, the dorsal lobe extremely small (Fig. 10). Dorsal ray stout and dividing close to its distal extremity, dichotomously, into four very small branches which support the dorsal lobe. Externo-dorsal rays stout and short, terminating some distance from the edge of the bursa. Lateral rays approximately of equal size; the postero-laterals and medio-laterals terminating in fine points on the bursal margin, the externo-laterals, however, having blunter extremities, bent slightly forwards. Ventro-ventral rays more slender and slightly shorter than the latero-ventrals. Genital cone well developed and bearing at its apex a pair of conspicuous papillae similar to those present in the type-species.

Spicules 0·18 to 0·2 mm. in length, the more highly chitinized portions appearing divided into two unequal branches (Fig. 10). Gubernaculum absent.

Female 13 to 14·5 mm. in length, with a maximum thickness of 0·22 mm. Head 0·038 mm. broad. Oesophagus 1 to 1·1 mm. in length.

Anus 0·13 mm. from the posterior extremity of the body. The body narrows suddenly just behind the anal opening, giving rise to a characteristic tail region similar to that of the type-species (Fig. 9).

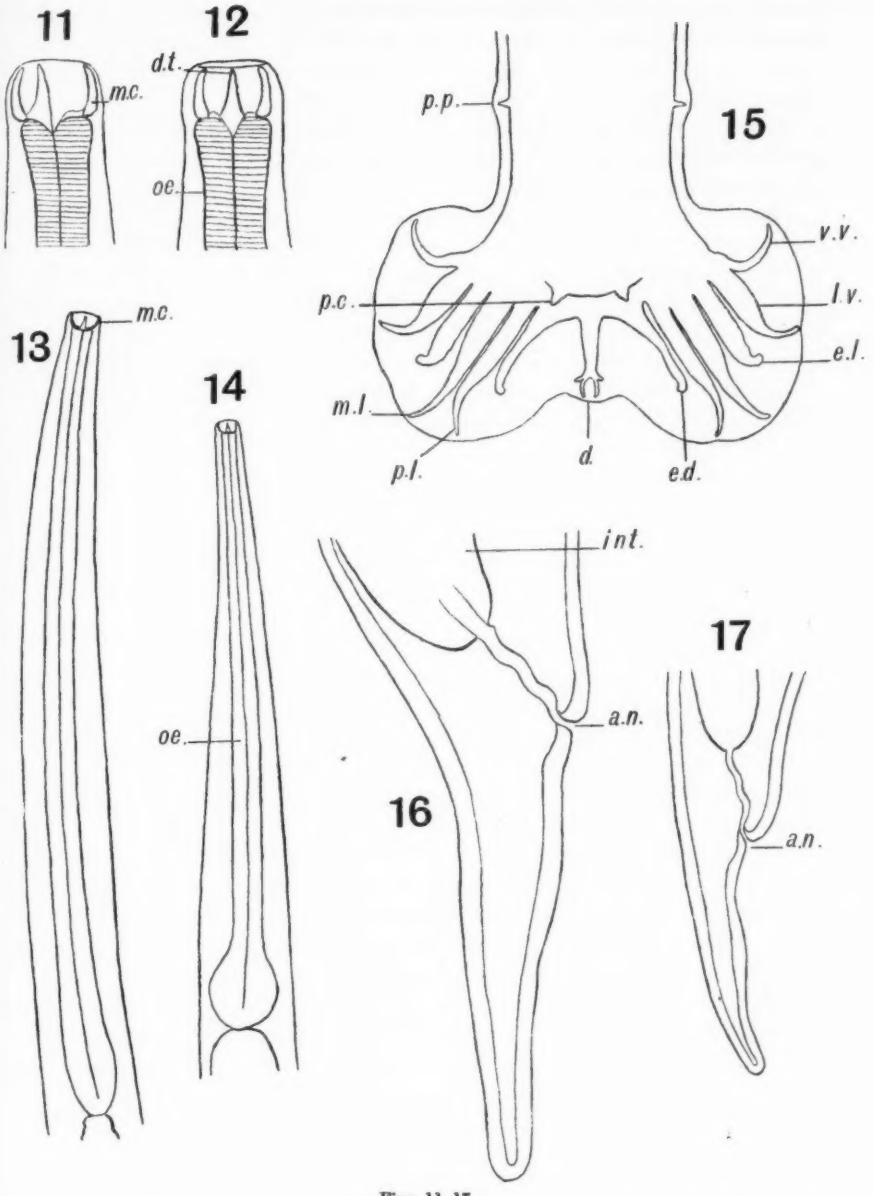
Vulva in the form of a transverse slit on a slight elevation of the body-wall, 2·7 to 3·2 mm. from the posterior extremity. The ovejectors have a combined length (including the sphincters) of 0·46 mm. Eggs 0·08 to 0·09 mm. by 0·05 mm.

Genus **Amidostomum** Railliet et Henry, 1909.

Amidostomum raillieti Skrjabin, 1916.

595. From *Fulica atra*, stomach-wall.
611. ,, *Fulica*. Loc., "Pyramiden."
614. ,, *Fulica*.

The specimens of *Amidostomum* from *Fulica atra* agree in their general measurements and in the majority of their characters with the form described from the same host by Skrjabin (1916) as *A. raillieti*, I have little doubt that they must be referred to this species. Skrjabin's description is however incomplete, since he was only able to observe male specimens, moreover (assuming that my identification is a correct one), it omits any reference to one of the most striking characters of the species, namely the shape of the oesophagus; I have, therefore, given a full description of the specimens in the Egyptian collection.



Figs. 11–17.

Amidostomum raillieti. Fig. 11. Head with mouth-capsule; lateral view. ×500. Fig. 12. Head with mouth capsule; dorsal view. ×500. Fig. 14. Anterior extremity to show oesophagus. ×120. Fig. 15. Male; posterior extremity ventral view. ×250. Fig. 17. Posterior extremity of female; lateral view. ×250.

Amidostomum anseris. Fig. 13. Anterior extremity to show oesophagus. ×120. Fig. 16. Posterior extremity of female; lateral view. ×250. (Lettering explained on p. 100.)

Males 5·5 to 6·5 mm., females 6·8 to 9·3 mm. in length; maximum thickness of body 0·12 to 0·22 mm. Head small, the mouth-capsule measuring only 0·024 to 0·029 mm. in width and provided with a conspicuous pointed tooth (Figs. 11 and 12).

Oesophagus 0·73 to 0·92 mm. in length, differing from that of the type-species, *A. anseris* (Zeder), in being swollen posteriorly to form a bulb-like enlargement (Figs. 13 and 14).

Male bursa, when spread out, measuring 0·27 mm. in width. Prebursal papillae present (Fig. 15). Ventro-ventral rays slender, curved towards the anterior margin of the bursa; latero-ventrals stouter and diverging from them. Externo-lateral rays terminating bluntly some distance from the bursal margin. Externo-dorsal rays short and also ending bluntly. Dorsal ray bifurcating at the base of the small dorsal lobe, each branch dividing again unequally. Genital cone short, provided with a pair of large papillae. Spicules 0·185 to 0·2 mm. long, their strongly chitinized portions appearing bifurcated distally. Gubernaculum present, measuring about 0·09 mm. in length.

Females with anus situated 0·11 to 0·145 mm. from the posterior extremity of the body, the tail in this species being considerably shorter than in the type species (Figs. 16 and 17). Tail tapering gradually to its extremity. Vulva 1·3 to 1·8 mm. from the posterior end. Combined length of ovejectors (including sphincters) 0·27 to 0·29 mm. Eggs 0·09 to 0·105 by 0·05 to 0·065 mm.

Amidostomum skrjabini sp.n.

577. From *Anser albifrons*.

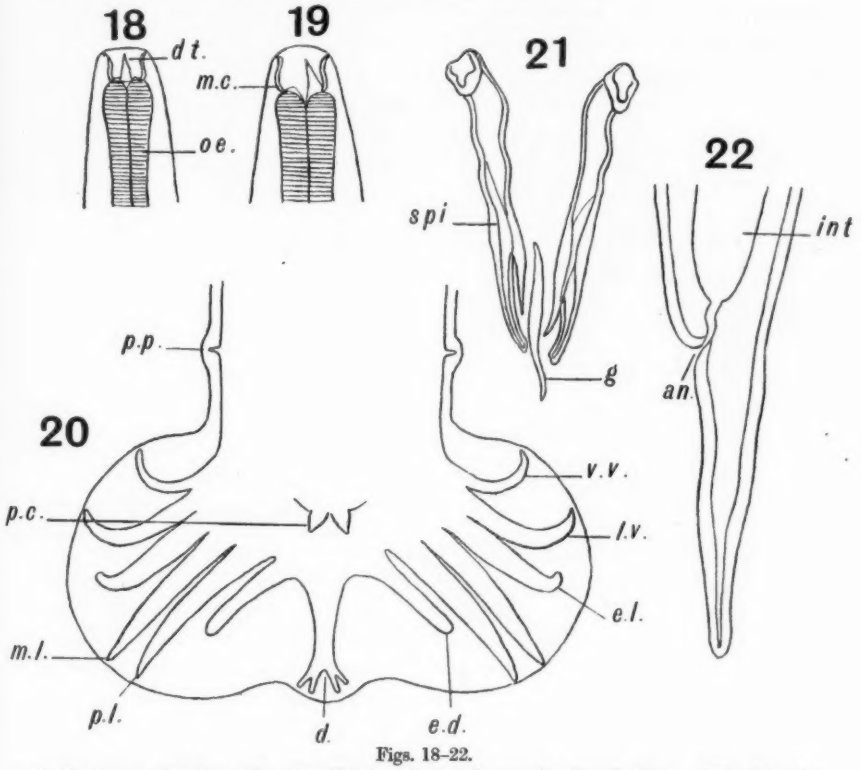
This small species of *Amidostomum* was at first mistaken for *A. henryi*, a form described by Skrjabin (1916) from *Vanellus cristatus*; a detailed examination of the worms showed, however, a certain number of characters irreconcilable with his diagnosis, they are, therefore, described as forming a new species, named *A. skrjabini*.

Males 7·5 to 8·8 mm., females 9 to 11 mm., in length. Body colourless with transversely striated cuticle, its maximum thickness 0·1 to 0·13 mm. in the males, 0·1 to 0·12 mm. in the females. Head very small, the buccal capsule measuring only 0·011 to 0·015 mm. in breadth, *i.e.* even less than that of *A. henryi*. The walls of the buccal capsule appear thinner and less highly chitinized than those of other species, the long, pointed dorsal tooth being also weak (Figs. 18 and 19). Oesophagus 0·55 to 0·62 mm. in length, in shape resembling that of the type species, being devoid of a posterior swelling.

Male bursa (Fig. 20) measuring about 0·2 mm. in width when spread out. The arrangement of the bursal rays recalls that of *A. railleti*, differing from *A. henryi* in that the externo-lateral rays are longer and have their tips bent slightly forwards. The dorsal ray splits into two branches distally, at the base of the small dorsal lobe of the bursa, each of these divides again into two smaller and approximately equal branches. Genital cone with a pair of conspicuous papillae. Prebursal papillae occur on the body, just in front of

the base of the bursa. Spicules 0·115 to 0·125 mm. long, in their general form resembling those of other species of *Amidostomum* (Fig. 21). Gubernaculum slender, 0·06 to 0·08 mm. long.

Females with anus 0·19 to 0·22 mm. from the posterior extremity, the gradually tapering tail (Fig. 22) being thus slightly longer than that of *A. raillieti*. Vulva a simple transverse slit 1·73 to 2·1 mm. from the posterior end of the body. Eggs 0·07 to 0·08 by 0·04 to 0·05 mm.



Figs. 18–22.

Amidostomum skrjabini. Fig. 18. Head with mouth-capsule; dorsal view. ×500. Fig. 19. Lateral view. ×600. Fig. 20. Male; posterior extremity; ventral view. ×400. Fig. 21. Male spicules and gubernaculum; ventral view. ×400. Fig. 22. Posterior extremity of female; lateral view. ×250. (Lettering explained on p. 100.)

Genus **Pseudamidostomum** gen.n.

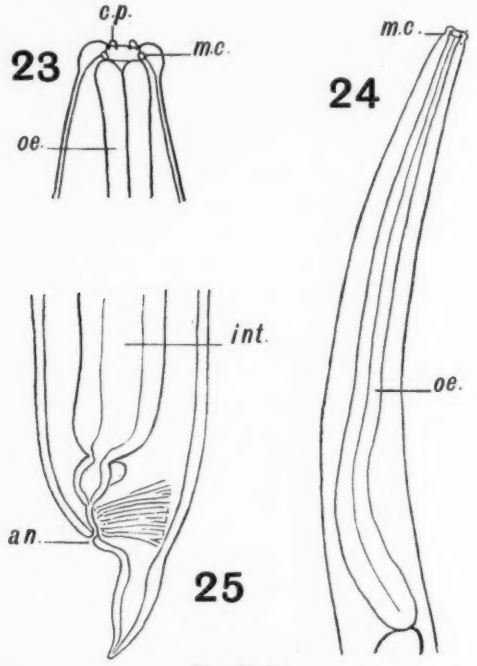
With the specimens of *Amidostomum raillieti* from *Fulica atra* were three females worms which, while bearing a superficial resemblance to them, proved to belong to a distinct species, which on account of certain characters, especially of the head-region, could not be included in *Amidostomum* and for which the new genus *Pseudamidostomum* is proposed.

Pseudamidostomum loossi sp.n.

595 (part). From *Fulica atra*, stomach-wall.

Body colourless, 7·3 to 7·8 mm. in length with a maximum breadth of 0·16 to 0·17 mm., as in species of *Amidostomum* tapering markedly towards the anterior extremity, the breadth of the head measuring only 0·026 to 0·028 mm.

Cuticle of head slightly expanded (Fig. 23); four conspicuous head-papillae, submedian in position, surrounding the small, circular mouth-opening. Mouth leading into a broad and very short buccal capsule (0·012 mm. in breadth), without teeth.



Figs. 23–25.

Pseudamidostomum loossi. Fig. 23. Head of female; lateral view. ×500. Fig. 24. Anterior extremity of female, to show oesophagus. ×120. Fig. 25. Posterior extremity of female; lateral view. ×250. (Lettering explained on p. 100.)

Oesophagus long, cylindrical and somewhat club-shaped (Fig. 24), measuring 0·8 to 0·93 mm. in length. Anus 0·07 to 0·11 mm. from the posterior extremity of the body; body narrowing suddenly behind the level of the anus, giving rise to a tail-region recalling that of *Epomidiostomum* (Fig. 25).

Vulva situated 1·7 to 1·75 mm. from the posterior extremity. Combined length of ovejectors (including sphincters) about 0·325 mm.; uteri divergent. Eggs 0·057 to 0·069 by 0·037 to 0·042 mm.

Genus **Heligmosomum** Railliet et Henry, 1909.

Heligmosomum muris Yokogawa, 1920.

From rat, stomach.

A few specimens, in a very poor state of preservation, are referred, provisionally, to this species.

Family STRONGYLIDAE.

Genus **Strongylus** Müller, 1780.

Strongylus equinus (Müller, 1780).

556. From horse.

Strongylus (*Alfortia*) *edentatus* (Looss, 1900).

103*. From *Equus caballus*. Loc., Cairo.

Strongylus (*Delafondia*) *vulgaris* (Looss, 1900).

101*, 102*. From *Equus asinus*. Loc., Cairo.

Genus **Cylicostomum** Railliet et Henry, 1902.

Cylicostomum longibursatum Yorke and Macfie, 1918.

545. From *Equus asinus*.

Cylicostomum calicatum (Looss, 1900).

549. From *Equus asinus*.

Cylicostomum alveatum (Looss, 1902).

111*. From *Equus asinus*, colon. Loc., Cairo.

Cylicostomum aegyptiacum (Railliet, 1923).

549. From *Equus asinus*.

Railliet has pointed out that Looss had no valid reason for applying the name *tetracanthum* to this species of *Cylicostomum*, which is most certainly not the one upon which Mehlis' original description was based. Le Roux (1924) has further shown that the species selected by Looss as the type-species is normally a parasite of the donkey and not of the horse, I have therefore accepted Railliet's new name for the common Egyptian form. I agree with Le Roux that Railliet's choice of *C. insigne* as the true "*Strongylus tetracanthus* Mehlis" is equally unfortunate, and consider, under the circumstances, that the latter had best be regarded as a *nomen nudum*.

Cylicostomum labiatum (Looss, 1902).

549. From *Equus asinus*.

110*. ,, *Equus asinus*. Loc., Cairo.

Cylicostomum coronatum (Looss, 1900).

114*. From *Equus caballus*. Loc., Cairo.

Cylicostomum nassatum (Looss, 1900).

549. From *Equus asinus*.

109*. ,, *Equus asinus*. Loc., Cairo.

Cylicostomum radiatum (Looss, 1900).

549. From *Equus asinus*.
113*. ,, *Equus asinus*. Loc., Cairo.

Cylicostomum auriculatum (Looss, 1900).

115*. From *Equus asinus*. Loc., Cairo.

Cylicostomum elongatum (Looss, 1900).

112*. From *Equus asinus*. Loc., Cairo.

Cylicostomum bicoronatum (Looss, 1900).

545. From *Equus asinus*.
116*. ,, *Equus asinus*. Loc., Cairo.

Genus **Ancylostoma** Dubini, 1843.

Ancylostoma caninum (Ercolani, 1859).

510 (part), 544. From Fennec Fox.
72*, 121*. ,, *Canis familiaris*. Loc., Cairo.

Genus **Oesophagostomum** Molin, 1861.

Oesophagostomum venulosum (Rudolphi, 1809).

559. From sheep.

Genus **Kalicephalus** Molin, 1861.

Kalicephalus minutus (Baylis and Daubney, 1922).

547. From *Naja haje*, oesophagus.

The specimens from *N. haje* are all females, they slightly exceed in size the type-specimens from the Indian cobra, measuring 5·9 to 6·7 mm. in length; they, however, agree in the general characters and in the relative measurements of the more important organs. Since the main distinguishing features of this species are to be found in the male organs (cf. Ortlepp, 1923), in the absence of males the identification must be considered a provisional one.

Kalicephalus appendiculatus Molin, 1861.

552. From *Dipsadomorphus irregularis*.

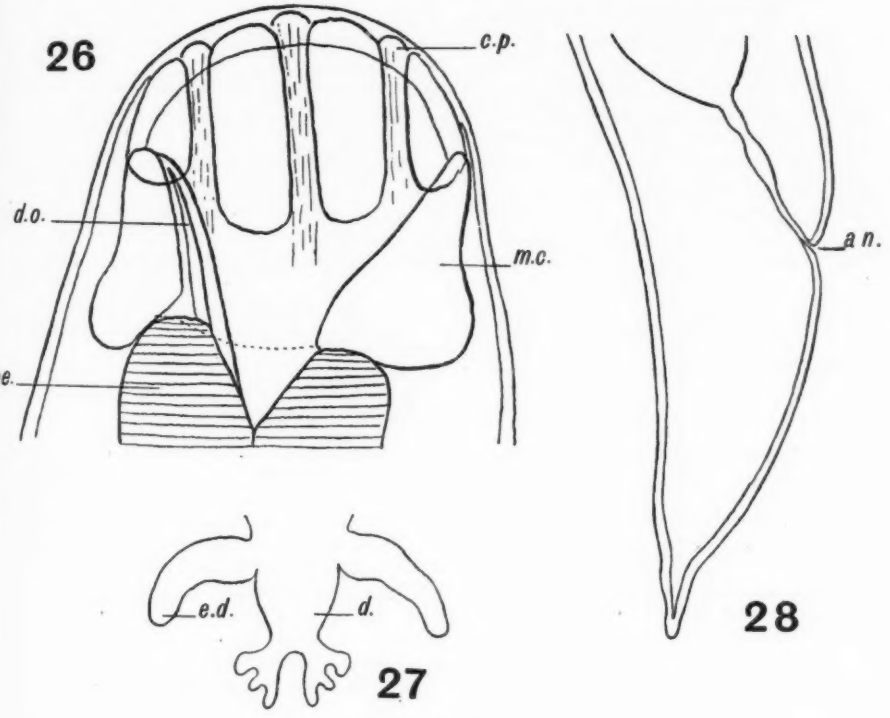
These specimens certainly belong to the same species as the worms from the same host in the Willey collection, identified by Stossich (in Shipley, 1900) as *Sclerostomum appendiculatum*; this species belongs to the genus *Kalicephalus s. str.* (Ortlepp, 1923).

The species is a short and rather stout one, in the specimens before me the males measuring 4 to 5·3 mm. in length, and the single female 5·8 mm., the maximum thickness being 0·26 to 0·28 and 0·34 mm., respectively.

The head is only slightly less broad than the body in the oesophageal region, measuring 0·21 to 0·26 mm. in dorso-ventral diameter; it is not separated from the body by a constriction. The anterior extremity of the head is rounded and almost bilaterally symmetrical (Fig. 26). The buccal cavity is 0·17 to

0·21 mm. deep; the duct of the oesophageal gland extends more than half the length of the buccal capsule and is 0·1 to 0·12 mm. long. The oesophagus is short and thick, having a length of 0·43 to 0·51 mm.

In the males the trilobed bursa is longer than broad; the dorsal ray (Fig. 27) is short, and divides into two short branches, each of which divides



Figs. 26–28.

Kalicephalus appendiculatus. Fig. 26. Head of female; lateral view. ×250. Fig. 27. Dorsal and externo-dorsal rays of male bursa; dorsal view. ×250. Fig. 28. Posterior extremity of female; lateral view. ×250. (Lettering explained on p. 100.)

again into three, in a very characteristic manner; the externo-dorsal rays are short, stout and curved. The slender, fine-pointed spicules are equal and have a length of 0·36 mm.

In the female the tail (Fig. 28) is long and tapering, the distance from anus to posterior extremity being 0·26 mm. The vulva is situated 1·6 mm. from the posterior end of the body. Eggs 0·07 to 0·08 mm. in length.

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EXPLANATION OF LETTERING ON FIGURES.

an., anus; *c.*, genital cone; *c.e.* cephalic expansion of cuticle; *c.p.*, head-papilla; *c.sp.*, cuticular spines of neck-region; *d.*, dorsal ray of bursa; *d.o.*, duct of oesophageal gland; *d.t.*, dorsal tooth; *e.d.*, externo-dorsal ray of bursa; *e.l.*, externo-lateral ray of bursa; *g.*, gubernaculum; *int.*, intestine; *l.v.*, latero-ventral ray of bursa; *m.c.*, mouth-capsule; *m.l.*, medio-lateral ray of bursa; *oe.*, oesophagus; *p.c.*, papilla of genital cone; *p.l.*, postero-lateral ray of bursa; *p.p.*, prebursal papilla; *sp.*, cephalic spine; *spi.*, male spicule; *t.m.*, terminal membrane of spicule; *t.s.*, terminal spike of tail; *v.p.*, ventro-lateral papilla of tail; *v.v.*, ventro-ventral ray of bursa.

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FURTHER OBSERVATIONS ON SOUTH AFRICAN LARVAL TREMATODES.

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(With Plates VI and VII and 1 Text-figure.)

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I. INTRODUCTION.

During the four years since the writer last published on South African larval trematodes (Faust, 1921), Doctor F. G. Cawston has sent him for identification nearly one hundred vials of material representing the trematode infections collected from molluscs in Natal (including Zululand), the Cape, Orange Free State, Basutoland, and Lourenço Marques (Portuguese East Africa). Much of this material has been found to belong to the same species and to originate from the same habitats as that from previous collections. Some of the previously described species have been collected from new hosts or from new habitats. There is, in addition, a relatively large number of new species in the collection which are here described.

Cawston (1923) has already assembled a useful tabulation of described species of South African larval trematodes, their hosts, and localities from which he collected his material. Most of this material has been sent to the writer for identification. With the exception of one species, *Bucephalopsis modiolae*, from an earlier collection but not previously described, the material in this paper has to do with specimens collected and sent to the writer within the past three years.

II. SPECIES IN THE COLLECTION.

Of the material well-preserved and sufficiently mature for identification, there are fourteen species not previously described from the area, thirteen of which are new to science. They involve the following groups:

1. Fork-tailed cercariae—four;
2. Gasterostome larva—one;
3. Echinostome cercaria—one;
4. Amphistome cercaria—one;
5. Cystophorous cercaria—one;
6. Xiphidiocercariae—five.

In every instance there has been an abundance of each described species for study and comparison, in some cases amounting to thousands of cercariae of the same species. In no case has a new species been described without a study of ten mature cercariae.

III. DESCRIPTION OF SPECIES.

Fork-Tailed Cercariae.

1. **Cercaria sewelli** nov. spec. (Pl. VI, figs. 1 *a*–1 *c*).

Hosts and Habitats: *Burnupia trapezoidea* Bttg. at Schuttes' Draai, Caledon River, on the Basutoland border of the Orange Free State; also from *Burnupia capensis* at Escombe, Natal.

This single-suckered, dorsally-keeled fork-tailed cercaria bears a general resemblance to *Cercaria cristata* La Valette, found by that investigator in *Lymnaea stagnalis* near Berlin (1855). It is, however, much more closely related to *Cercaria indica XXXIX* Sewell, 1922, from which it differs only in a few specific points. In view of Sewell's carefully detailed work on the Indian species it is proposed to name this form in his honour.

Cercaria sewelli has a body length of 0·15 mm. and a body breadth of 0·048 mm. It is almost as thick as it is broad. The tail trunk has a length of 0·18 mm. and the furci a length of 0·07 mm. The tail measures 0·02 mm. in diameter at its point of attachment to the body.

The body proper is separated from the anterior cephalic portion of the larva (*h*) by a distinct circular constriction. The dorsum bears an integumentary keel, lunar in outline and about 15μ wide near its middle. This keel prevents the larva from lying on its dorsal side, so it is most commonly seen from the lateral aspect (Fig. 1 *b*). As in *Cercaria indica XXXIX* the cephalic

end of *C. sewelli* is beset with a hood of integumentary spines; but unlike the former, *C. sewelli* possesses no caudal spines. In the middle of the dorsal side of the body on either side of the keel is a pair of eye-spots (*oc*) with pigmented centres. This pigmentation distinguishes the species under consideration not only from the Indian cercaria (*l.c.*) but also from the cercaria of *Sanguinicola inermis* Plehn (Odhner, 1911; Scheuring, 1923).

The most conspicuous internal feature of *Cercaria sewelli* consists in two pairs of cephalic secretory glands (*cg*), granular in character and oxyphilic in reaction, lying posterior to the eye-spots, with ducts (*cgd*) opening through reinforced duct openings at the anterior end of the larva. These latter are less conspicuous than those in *C. indica XXXIX* (Sewell, *l.c.*). Aside from the main collecting tubules and the bladder the excretory system in the body of the worm has not been studied. It is anticipated, however, that it will be identical with that of *C. indica XXXIX*, which Sewell has worked out so beautifully, consisting of two anterior and one posterior capillary and flame-cell on either side of the body, draining into the main collecting tubule. The collecting apparatus in the tail, consisting of a main tubule in the trunk and a single branched tubule opening through a pore at the tip of each furcus, corresponds exactly with Sewell's description and figure. No digestive tract has been observed. The genital anlage (*ga*) consists of an oval mass just in front of the excretory bladder.

Cercaria sewelli develops in an oval sporocyst within which only one mature larva and a few germ balls are found.

In view of the genetic relationship between this type of furcocercous larva and *Sanguinicola*, as hypothecated by Odhner (1911) from Looss's observations and experiments, and more recently proved experimentally by Scheuring (1923), and in view of Woodland's recent finding (1923) of a third *Sanguinicola* (*S. chalmersi* Odhner, 1924) from siluroid fishes in the Sudan, the presence of the larva of this group in South Africa is of unusual interest. It either indicates that the Sudan species of *Sanguinicola* also occurs in the Basutoland area and in Natal, or that another closely related form exists in South Africa. Since Sewell's *Cercaria indica XXXIX*, *C. indica IX* and *C. indica XIII* also represent cercarial stages of other specifically different but closely related species of monostomal blood-flukes, six and possibly seven such species are now known from the Euraso-African area. A search in the blood of fresh-water fishes occurring in the waters where *C. sewelli* was found will certainly yield the adult *Sanguinicola* of which this cercaria is the larva.

2. **Cercaria milleri** nov. spec. (Pl. VI, figs. 2 *a*–2 *c*).

HOSTS: *Lymnaea natalensis* and *Segmentina planodiscus*.
HABITAT: Durban, Natal.

This large distomate fork-tailed cercaria, for which the name *Cercaria milleri* is proposed, is a form closely resembling *Cercaria elvae* Miller, 1923. The larva has an elongate body measuring 0·28 mm. in length by 0·064 mm. in width

and 0·70 mm. in depth in the region of the ventral sucker. The tail trunk has a length of 0·4 mm., while the furci are about 0·2 mm. long. The furci have keeled margins (Pl. VI, fig. 2 *c*). The integument of both body and tail is aspinose. A pair of pigmented eye-spots is seen on the dorsum about one-third the body distance behind the anterior end.

The anterior third of the body consists of a large oral bulbus, within which is found the anterior suctorial apparatus and through which run the paired cephalic secretory ducts (*cd*) and the anterior anlage of the digestive tract (*o*). Faust and Meleney (1924) have shown for the cercaria of *Schistosoma japonicum* that the portion of the anterior bulbus in front of the oral opening is an ephemeral larval feature, disappearing soon after the cercaria penetrates the mammalian host. It is believed that this organ becomes modified in a similar fashion in *C. milleri* and other related forms. The ventral sucker lies two-thirds the body distance toward the posterior end (*vs*). It protrudes conspicuously out from the subintegumentary tissues so that the larva is usually seen lying on its side (Pl. VI, fig. 2 *a*).

The digestive tract in *C. milleri* is similar to that of *C. elvae*, consisting of a long capillary tube which forks to form short caeca a short distance in front of the ventral sucker. It is not provided with a pharynx. The cephalic secretory glands consist of two pairs, oxyphilic in reaction and provided with large nuclei possessing a central karyosome and heavily clumped masses of chromatin lining the nuclear membrane. The four ducts through which these glands empty emerge from the anterior surface of the anterior bulbus (*do*) and are heavily reinforced around their openings. In addition to these glands there is a single oral (head) gland (*og*), the contents of which are basophilic in reaction and fill a considerable portion of the anterior bulbus. Only the bladder of the excretory system has been made out in the material studied. There seems considerable likelihood, however, that the excretory system in this species is similar to that of *C. elvae* and of *C. bombayensis XXX* Soparkar (1921), conforming to the pattern: 2 [(2 + 1) + (1 + 3)], as designated by the writer (Faust, 1924, Table II). The genital anlage consists of an oval mass of cells ventral in position directly behind the ventral sucker.

C. milleri develops in an elongate sporocyst in which several larvae are produced synchronously.

3. **Cercaria syncytadena** nov. spec. (Pl. VI, figs. 3 *a*–3 *c*).

HOST: *Segmentina planodiscus.*

HABITAT: Durban, Natal.

Cercaria syncytadena is a distomate fork-tailed larva with a body measuring 0·2 mm. in length by 0·08 mm. in greatest breadth, and a tail with a trunk 0·4 mm. in length and furci 0·16 mm. long. The furci have keels on either side as do those of *C. milleri*. Conspicuous round pigmented eye-spots (*oc*) are seen on the dorsal surface of the body, about one-third the body distance from the anterior end. The entire worm is aspinose.

The oral opening consists of a small orifice slightly ventral in position with respect to the anterior end. The simple unbranched tubule can be traced inward as far as the plane of the eye-spots where it appears to end. The ventral sucker is a small circular sphincter measuring about 20μ in diameter and is situated about two-thirds the body distance toward the posterior end of the body. The cephalic secretory glands consist of two kinds, (*a*) three anterior pairs of unicellular glands with minute granules, having an oxyphilic reaction (cg_1), and (*b*) one pair of multinucleate glands (cg_2) with a basophilic reaction. These four pairs have ducts which traverse the head tissues and open through conspicuous duct pores (*do*) at the anterior margin of the larva. There is likewise an oral (head) gland (*og*) basophilic in reaction, which opens mesad between the openings of the cephalic glands. Only the bladder of the excretory system is to be seen in the preserved specimens, but the cercaria so nearly resembles *C. indica XXV* Sewell, 1922, that the flame-cell formula for the latter (designated by Faust, 1924, Table II as: 2 [(2 + 1) + 2] for this group) will probably "fit" the species under consideration. The genital anlage of *C. syncytadena* consists of a compressed mass of cells about half-way between the ventral sucker and the posterior extremity of the body.

The parthenita is a sacculate sporocyst in which several cercariae develop synchronously.

4. **Cercaria gigantosoma** nov. spec. (Pl. VI, figs. 4 *a*–4 *b*).

HOST: *Isidora africana.*

HABITAT: Municipal gardens, Lourenço Marques, P. E. Africa.

Cercaria gigantosoma bears certain relationships to *Cercaria vivax* Sonsino, 1892 and to *C. indica XV* Sewell, 1922. It has an oval-elongate body, measuring 0·27 mm. long by 0·1 mm. broad, and a tail with a trunk and paired furci which are each about the same length as the body. Both body and tail are covered with conspicuous integumentary spines.

At the anterior end of the body there is a muscular oral sucker (*os*), 56μ long and 35μ in cross-section. The ventral sucker lies in the posterior third of the body and measures 35 × 30μ.

Within the oral sucker the digestive tract consists of a small spherical pharynx (*ca.* 18μ in cross-section), a short oesophagus, and a pair of caeca which enlarge in the vicinity of the ventral sucker to form irregular solid pouches, with a basophilic reaction, in the centres of which is found a single pair of nuclei (*c*). Such a condition is not recorded for *C. vivax* nor for *C. indica XV*. The cephalic secretory glands consist of two pairs, irregular in outline and oxyphilic in reaction. Their ducts open through reinforced tips just lateral to the anterior margin of the oral sucker. Langeron (1924: 40) describes a corona of glandular cells around the orifice of *C. vivax*. These have not been observed in *C. gigantosoma*.

Details of the excretory system have not been observed, although the bladder is known to be small, while the collecting tubules in the tail furci

open outward about half-way toward the distal ends of the furci. It has not been possible to observe the complicated system of collecting tubules such as Sewell found in *Cercaria indica XV* (1922, Pl. XXXI, figs. 1, 2). The genital anlage (*ga*) consists of a small triangular mass of cells situated just in front of the excretory bladder.

Cercaria gigantosoma develops in large sacculate sporocysts, the posterior end of which is attenuate and muscular. From the centre of this tip a germinal rachis develops (Pl. VI, fig. 4 *b*), proliferating the germ-ball into the body cavity of the parthenita.

5. The Cercariae of the Human Blood-Flukes in South Africa.

Among the early collections of larval flukes made by Dr Cawston from Natal (1915 *et seq.*) were certain furcocercous larvae from *Isidora* (*Physopsis*) *africana*, which Dr Cawston believed to be human schistosome cercariae in view of (1) the prevalence of bilharziosis in Natal, and (2) the experimental work of Leiper (1915) in Egypt incriminating similar fork-tailed cercariae as the larvae of *Schistosoma haematobium* and *S. mansoni*. Certain specimens from these collections which were sent to Prof. H. B. Ward, at Urbana, Illinois, were examined by the writer (1918–19), who had previously had an opportunity to examine (1) *Katayama nosophora* containing living cercariae of *Schistosoma japonicum*, secured through the kindness of Prof. S. O. Yoshida of Osaka, Japan, and (2) heavily infected and well-preserved specimens of *Planorbis guadeloupensis* from Dr Juan Iturbe of Caracas, Venezuela, containing fork-tailed larvae experimentally proved to be cercariae of *Schistosoma mansoni*. The close agreement of certain of the South African cercariae with those from Japan and South America indicated that the former were undoubtedly closely related forms, while the epidemiological evidence pointed to the conclusion that the South African larvae were human blood-fluke cercariae. The writer, therefore, diagnosed these South African forms as cercariae of *Schistosoma haematobium* and in 1919 (Faust, 1919 *a*: 167) published a table for the differentiation of species of human schistosome cercariae. There was the greater justification for emphasising the differences found among these closely related larvae, in view of the fact that Cort (1919) had just published a detailed account of the morphology of the Japanese schistosome cercariae which agreed in all essential points with the observations made by the writer on that species. It was realised, however, that Leiper (1918: 39) believed that only experimental infection of mammals would determine the systematic position of such cercariae. While such confirmatory procedure was admittedly desirable it was not possible of accomplishment by the writer because the non-operculate gasteropods which harboured the two types of bilharzia larvae could not be transported any such distance alive. In view of these facts and after a study of the Japanese, Venezuelan and South African fork-tailed cercariae, as well as other related living cercariae

which were obtainable in the United States, the following conclusions were reached:

(1) *The essential differentiating features of the apharyngeal fork-tailed cercariae consisted* not in the digestive, excretory or genital organs but *in the number and microchemical reactions of the secretory cells*[1].

(2) *These details of structure essential for diagnosis could be determined from well-preserved material as well as from fresh material.* In fact, study of preserved material was found to be absolutely essential for complete diagnosis. The writer holds to the essential points stated in this thesis even more firmly to-day than at the time when the thesis was proposed. Such conviction has been based on (1) previous study of relationships existing in cercariae available for experimental study, (2) prediction of systematic relationships on the basis of known larval characters, and (3) verification of the theory by experimental proof. In fact, the case is not overstated by asserting that experimental work on trematodes is usually unconvincing unless there is a careful morphological description checking each stage of development of the species involved.

The writer's finding of the cercaria of *Schistosoma mansoni* and of *Cercaria octadena* (suggested as possibly the larval stage of *Schistosoma bovis*) in *Isidora africana*, from the same habitats in Natal and at times from the same specimens of snails from which the cercariae of *Schistosoma haematobium* were found, precipitated criticism from several sources. Cawston (1920), who had not personally seen cases of schistosomiasis mansoni in South Africa up to that time, was inclined to doubt the presence of the larvae in the area, although Porter had seen both human cases of the infection (1918) and the cercariae in *Isidora africana* (Jan. 1920) previous to the time the writer's findings were published (June 1920). Later Cawston realised that *Schistosoma mansoni* was present in South Africa and agreed with the writer's diagnosis[2]. More recently Khalil (1922) and Blacklock and Thompson (1924) have subjected the writer's observations on South African mammalian schistosome cercariae to criticism, the former with respect to *Schistosoma mansoni*, the latter concerning *S. haematobium* larvae. It is hoped that the publication of the data in the writer's possession will serve to clear up the points of difference that have arisen over these larval schistosomes.

As far as the writer can determine the criticism regarding South African schistosome cercariae may be viewed from two standpoints:

[1] Some of these gave a reaction for *mucin* and were therefore designated as *mucin glands* (1919 *a*). Later (1921), when it was found that other glands were never found to contain mucin, it was suggested that the term "cephalic gland," originally used by Looss and recommended by Cort (1919), be utilised.

[2] At this time (Aug. 1920) Dr Cawston sent the writer the following information:

"You will be interested to hear that on June 14th I commenced to treat a boy of twelve and a half years who contracted infection with *Schistosoma mansoni* from the Mayville pools (Durban), where I obtained some of the *Physopsis africana* I sent you and which you found infested with the cercariae of *S. mansoni*. I have found about half a dozen of the lateral-spined ova in the urine as well as in a rectal wash, though the spine-pointed ova" (he means, of course, terminal spined ova) "are much the more numerous in the urine."

(1) *Theoretical, i.e.*, the justification of using morphological distinctions to differentiate schistosome larvae.

(2) *Practical, i.e.*, as to whether the source of the writer's material, its state of preservation, etc., warranted the writer in making the diagnosis in question.

(1) *Theoretical.*

Criticism of the general thesis which the writer originally advanced (1919) and which he still maintains, is one very difficult to meet. It is felt, however, that such criticism should not come from clinicians but from biologists who have a broad knowledge of the comparative biology and morphology of the group involved and who are not solely concerned with those forms directly involved in human infections. While certain details in the development of any hypothesis frequently need restatement in the light of additional knowledge, it is the main hypothesis and not its corollaries, which will either fall or be substantiated when subjected to the test. Cort (1919, 1921), Sewell (1919, 1922), Soparkar (1921) and more recently Miller (1923, 1924) and Langeron (1924), all of whom have approached the problem of differentiating larval trematodes from the angle of the biologist, have accepted the essential thesis involved in this discussion. Even Khalil (1922), and Blacklock and Thompson (1924), while denying the validity of this hypothesis, in attempting to show that the writer was not justified in his diagnosis of South African cercariae, have made use of the very morphological details which it presupposes and hypothecates. All evidence preponderates, therefore, in support of the view that the cephalic secretory glands of larval flukes, particularly those of the apharyngeal blood-fluke cercariae, constitute a valid and justifiable basis for differentiation of this group of cercariae.

(2) *Practical. Source and condition of material studied by the writer.*

(*a*) *Venezuelan material.*

In 1917 Dr Juan Iturbe sent to Prof. H. B. Ward representative specimens from his experimental study on schistosomiasis mansoni, in which Iturbe (1917) had been able to demonstrate that *Planorbis guadeloupensis* served as the molluscan host of the infection. While the writer (Faust, 1918) showed that Iturbe was wrong in identifying a natural infection of *Tetracotyle iturbei* in the snail as the "redial stage" of the experimental infection, there was no question at that time, nor has there been since, as to Iturbe's proof of the life-cycle of *S. mansoni*, of which the material sent to Prof. Ward and examined by the writer was an integral part. The infected snails and their parasitic progeny, which had been preserved in formalin, were found to be in an excellent state of preservation.

The cercariae from some of the infected livers of *Planorbis guadeloupensis* from this material were dissected out and stained and mounted entire. In other cases sections of the liver containing the cercariae were made and specially stained for study.

This staining consisted in using the ordinary Delafield haematoxylin as the fundamental tissue stain, and in counterstaining certain series of sections with Best's alum-carmine for comparison with other sections counterstained with eosin. The result from the alum-carmine preparations was very striking, since this dye was found to be specific for the granular inclusions of certain secretory cells having a basophilic reaction, beginning with the germ-ball stage and continuing until the cercariae were fully mature. It was because of the basophilic staining properties of these cells that the writer was able to pick out the differences between the cephalic secretory glands of the cercariae of *Schistosoma japonicum* and of *S. mansoni*. Microscopists who have seen these preparations have not hesitated to state that the material is well preserved and that the differentiation of the two types of glands is diagrammatically clear. The writer found (Faust, 1919 *a*) that there were in the cercariae of *S. mansoni* "2 pairs (of glands) with large nuclei and granular acidophilic cytoplasm; 4 pairs with small nuclei and basophilic slime contents." Khalil (1922: 6) claims to have found only five pairs of such glands in a larva which he designated as "the Cercaria of *Schistosomum mansoni*" secured from *Planorbis boissyi* near Cairo. Although the material was taken from the same species of snail which Leiper (1915) had demonstrated to harbour the cercaria of *S. mansoni* near Cairo there was *no experimental proof* that he was dealing with this species of larva. In following this argument to its conclusion it must be kept in mind that the material studied by the writer was from a known experimental source in a region in which only schistosomiasis mansoni is known. Even the most incredulous, therefore, cannot deny that (1) the source of the Venezuelan material in question is not subject to criticism; and that (2) the material was well preserved. Furthermore, the writer's method of preparing this material for study served admirably to differentiate the two types of secretory glands.

The writer has recently restudied the original slides from the Venezuelan material of *Planorbis guadeloupensis* containing cercariae of *S. mansoni*. His findings agree in every respect with those of his earlier study (1919). Details of the secretory glands of two of these specimens stained with haematoxylin and counterstained with Best's alum-carmine are shown in Figs. 5 (*a–c*) and 6 (*a–f*). These are carefully drawn camera lucida sketches, observed under a Leitz microscope possessing the best optical equipment. Figs. 5 (*a–c*) are three serial sagittal sections through the middle of the body of a typical cercaria. The two pairs of acidophilic glands (*acg*) are shown in black; the basophilic glands are in red. From a count through either the plane of the glands (*bcg*) or of the gland ducts (*bcgd*) eight separate individual structures can be obtained. The same holds equally true for sections cut in a transverse plane. Pl. VI, figs. 6 (*a–f*) are differentiated by the same colour scheme as Pl. VI, figs. 5 (*a–c*).

Because the sections are almost transversely cut the same ducts and even the glands occur in several sections. In sections 6*a*–6*c* eight ducts (*i.e.* 4 pairs) containing granules of the basophilic type of reaction can be counted. In

section 6*d* all of the glands but not all of the nuclei can be seen. In sections 6*c* and 6*d* combined all eight nuclei are found. It cannot be denied, therefore, that in the Venezuelan material the original findings of two pairs of acidophilic and four pairs of basophilic glands agree with the facts. The smaller number of glands found by Khalil (*l.c.*) cannot vitiate the evidence that the larger number has been consistently found in the Venezuelan material.

The discovery of similar cercariae in *Isidora africana* from Natal, with a similar number of cephalic secretory glands giving the same microchemical reactions, left no alternative for the writer but to label them "cercariae of *S. mansoni*."

(*b*) *South African material.*

(i) *Schistosoma haematobium.* The work of Blacklock and Thompson (1924) in Sierra Leone constitutes a convincing piece of research. In an area where they have found only vesical bilharziasis to be common they have demonstrated that a snail closely related to if not identical with *Isidora* (*Physopsis*) *globosa* can serve as experimental host, in which a cercaria matures that has been proved experimentally to develop into *Schistosoma haematobium*. Furthermore, carefully checked *toto* mounts and sections prepared by them from this material show there to be two anterior pairs of acidophilic glands and three posterior pairs of basophilic glands constantly present in their material. After a careful restudy of material from South Africa, and from Palestine, and after the preparation of fresh sections using Delafield's haematoxylin with a counterstain of Best's alum-carmine, *the writer* is able to state that he *is in full agreement with Blacklock and Thompson with respect to the number of glands in the cercaria of* S. haematobium. It may be added, by way of explanation, that freshly prepared *toto* mounts of well preserved specimens of the cercaria of *S. haematobium*, with or without eosin counterstain, give a similar picture to that which the writer first observed and described as the one prevailing in the cephalic secretory glands of cercariae of *S. haematobium* from *Isidora africana* from Natal, namely three pairs with granular acidophilic (?) cytoplasm. However, *toto* mounts, that have been allowed to "age" for a year or more, when carefully studied, can be seen to possess two types of glands, an anterior group of two pairs and a posterior group of three pairs. It is, therefore, highly advisable when dealing with such schistosome cercariae to use Best's alum-carmine counterstain on material previously sectioned and stained with haematoxylin or other fundamental tissue stain, in order to bring out this existing difference between the two types of cephalic glands now known to be present in this species of cercaria.

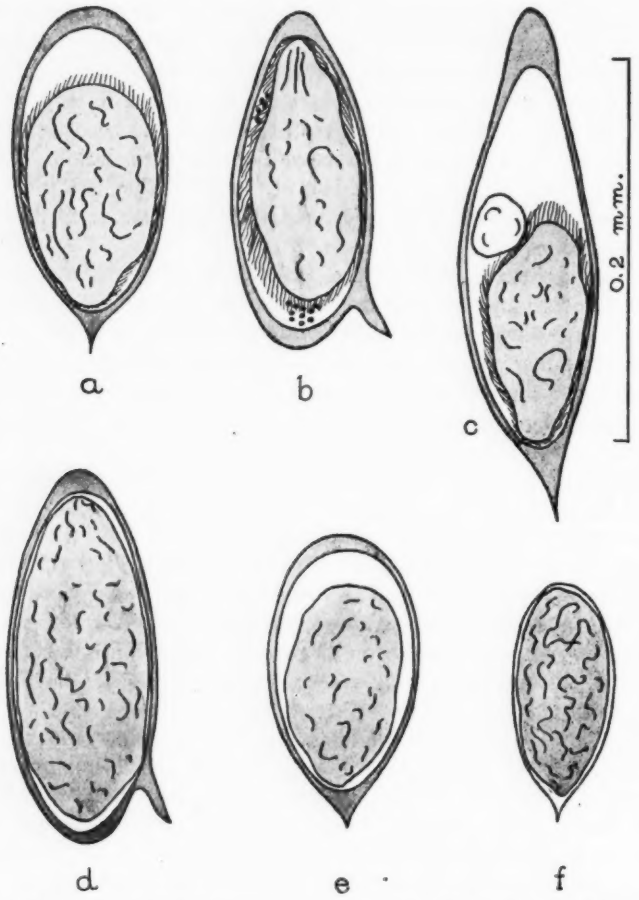
The writer's ability to agree with Blacklock and Thompson after re-examination of old material and preparation of new material from Natal, makes it possible to restate the writer's conviction that he was dealing with the cercaria of *S. haematobium* as the prevailing schistosome infection in *Isidora* (*Physopsis*) *africana*, which accords epidemiologically with the fact

that schistosomiasis haematobia is the prevailing human infection in that region. There is, moreover, experimental proof from Natal incriminating this blood-fluke cercaria, the one most commonly found in *Isidora* (*Physopsis*) *africana* in that area, as the larva of *Schistosoma haematobium*. Under date of September 7, 1920, Dr Cawston addressed the writer as follows: "Two guinea pigs were treated with schistosomes from *Physopsis africana* at Sydenham on the 5th of May, one had them injected subcutaneously, the other ate them on beans. On the 6th of September I found five adults in the injected guinea-pig—four males and one female *in copula*." These he sent the writer for identification. After study of the material, which had been sectioned and stained, the writer identified them as *Schistosoma haematobium* and wrote Dr Cawston (under date of December 24, 1920): "They are undoubtedly *Schistosoma haematobium*, for they have only four (4) testes, while all other known schistosomes have five or more."

(ii) *Schistosoma mansoni*. Re-examination of the Venezuelan material, and comparison with similar material from Natal (a minor mammalian schistosome infection in *Isidora africana* in that area) fully confirms the writer in his belief that he was dealing with the cercariae of *S. mansoni* when he diagnosed such material from Natal (Faust, 1920: 193). The presence of a lateral-spined schistosome ovum, preserved in the same vial of material in which there were *Isidora africana* livers containing cercariae of *S. mansoni* (Faust, 1921), may have been a unique coincidence as Blacklock and Thompson (*l.c.* p. 224) suggest, but it certainly was strong evidence that a case of schistosomiasis mansoni was present in the region from which Dr Cawston collected that particular specimen of *Isidora*. The subsequent finding of *Schistosoma mansoni* ova in a youth who had not been out of Natal and who frequently bathed in the same pools at Mayville where the *Isidora* (*Physopsis*) *africana* was obtained from which the writer diagnosed the "cercariae of *S. mansoni*" certainly constitutes the strongest confirmatory evidence that the most sceptical critic could demand.

(iii) *Schistosoma bovis*. Experimental evidence points to the genetic relationship of *Cercaria octadena* to *Schistosoma bovis* which is known to occur in this area. Under date of June 29, 1920, Dr Cawston wrote as follows: "Dr R. T. Leiper has no hesitation in diagnosing some adult schistosomes from one of my guinea-pigs as *Schistosoma bovis*, which have not previously been found in South Africa; but I have not yet traced the cow (the usual host) that infected the Physopsis used in the experiment." These guinea-pigs had been submitted to a mammalian schistosome infection from *Physopsis africana* and the adult worms, which were later recovered from them, proved to be *S. bovis*. In the meanwhile Dr Cawston had found eggs which he believed to be those of *S. bovis* in the urine of two Natal-born Indian boys, both of whom had been "living near and bathing in the infested pools at Sydenham." Under date of March 9, 1922 he wrote: "Dr Leiper found two (eggs) which he considered more like *S. bovis* than those of *S. haematobium*." Text-fig. 1

shows tracings from camera lucida drawings of ova from the urine of two boys who had never left Natal. Figs. *a*, *b*, and *d* are from one boy and Figs. *c*, *e*, and *f* are from the other boy. It is evident that *a*, *e*, and *f* are ova of *S. haematobium*; that *b* and *d* are ova of *S. mansoni*; and it seems highly probable



Text-fig. 1. Schistosoma eggs from human cases in the vicinity of Durban, Natal, from patients frequenting the pools harbouring infected *Isidora* (*Physopsis*) *africana*.

that *c* is the ovum of *S. bovis*. This ovum corresponds exactly with ova from specimens obtained by Dr Cawston from an experimentally infected guinea-pig, the adult worms of which were found to be *S. bovis*. In fact, the "cow," hypothecated by Dr Cawston, may not be necessarily involved in the *Schistosoma bovis* life-cycle in Natal; man may possibly serve in this capacity.

The present situation with respect to the three South African mammalian schistosome cercariae under consideration may be stated as follows:

(1) *Isidora africana* from Natal is known to harbour three species of mammalian schistosome cercariae.

(2) One of these, originally diagnosed as the "Cercaria of *S. haematobium*," is found by comparison with the data furnished by Blacklock and Thompson to correspond to their form, known experimentally to be the cercaria of *S. haematobium*.

(3) A second cercaria corresponds exactly with material from Venezuela, which is known experimentally to be the cercaria of *S. mansoni*.

(4) A third cercaria, designated by the writer as *C. octadena* (Faust, 1921), is most likely the fork-tailed larva of *S. bovis*, obtained experimentally from guinea-pigs submitted to infection with mammalian schistosome cercariae from *Isidora* (*Physopsis*) *africana*; and also found as a natural infection in native Natal boys.

(5) These three cercariae can be distinguished from one another as well as from the cercariae of *S. japonicum* and of *S. spindalis* on the basis of the cephalic secretory glands which are constant in number for each species and

Table I. *Diagnosis of the Three Common Species of Human Schistosome Cercariae.*

	S. haematobium	*S. mansoni*	*S. japonicum*
Size:			
Body	140–240 × 57–100 μ	140–190 × 50–75 μ	100–160 × 40–66 μ
Tail trunk	175–250 × 35–50 μ	200–260 × 25–40 μ	140–160 × 20–35 μ
Furci	60–100 μ long	50–75 μ long	50–75 μ long
Oral sucker	60 μ in transection × 64 μ in length	30–60 μ in transection	33 μ in transection × 54 μ in length
Cephalic secretory glands*	2 pairs with large nuclei and granular acidophilic cytoplasm; 3 pairs with basophilic reaction (Best's alum-carmine differentiation)	2 pairs with large nuclei and granular acidophilic cytoplasm; 4 pairs with small nuclei and basophilic slime contents (Best's alum-carmine differentiation)	5 pairs with large nuclei and granular acidophilic cytoplasm (not positive to Best's alum-carmine stain)
Cephalic gland ducts	Moderately thick	Very thick	Very thick
Duct openings	At anterior end of oral sucker; capped by 5 pairs of hollow piercing spines	At anterior end of oral sucker; capped by 6 pairs of hollow, piercing spines	At anterior end of oral sucker; capped by 5 pairs of hollow, piercing spines
Oral gland (head gland of Cort)	Absent	Absent (?)	One large gland present
Germ cells	Several large cells posterior to acetabulum	Many cells at posterior end of body	Clustered mass of cells just behind acetabulum
Parthenita	Sporocyst	Sporocyst	Sporocyst
Host	*Isidora contorta* (Egypt); *Isidora africana* (Natal); *Isidora globosa* (Sierra Leone); *Planorbis metidjensis* (Morocco).	*Planorbis boissyi* (Egypt); *Planorbis guadeloupensis* (Venezuela, Brazil, etc.); *Isidora africana* (Natal).	Oncomelania species, including Katayama (China and Japan)

* Differentiation constantly found in the cercariae of *S. haematobium* and *S. mansoni* from the germ-ball stage to mature cercariae.

which have, at least in mature cercariae, specific acidophilic and basophilic properties which allow of their definite differentiation. The accompanying table (Table I), modified to accord with the recent findings, replaces the one previously proposed by the writer (Faust, 1919 *a*).

(6) These data are consistent with known epidemiological data, viz., the presence of *Schistosoma haematobium*, *S. mansoni* and *S. bovis* as parasites of man in the exact geographical location from which the Isidorae harbouring the cercariae were obtained.

6. **Bucephalopsis modiolae** nov. spec. (Pl. VII, figs. 7 *a*–7 *f*).

HOST: *Modiola capensis*.

HABITAT: Umgeni River mouth, Durban, Natal; also Illovo River, Natal south coast.

This interesting gasterostome larva was first collected by Dr Cawston in January 1921 in the bivalve, *Modiola capensis*, found on floating wood taken from the waters of the Umgeni River. It was secured a second time attached to stems of water lilies and to rushes in the Illovo River. It is a relatively simple larva, with a body oval-elongate in shape, measuring from 0·28 mm. to 0·3 mm. in length by 0·070 mm. to 0·085 mm. in breadth. It possesses a caudal appendage with a rounded compressed trunk (Pl. VII, fig. 7 *e*, *tb*) and a pair of elongate furcal processes (*cf*) which, when contracted, have about the same length as the body, but which on extension may measure twice the body length. The anterior sucker (*as*) is an oval muscular attachment organ measuring 40μ in cross-section by 60μ in length. The ventral sucker (*vs*) serves both as the ventral organ of attachment and as the orifice to the digestive tract. It is a conspicuous muscular organ, oval in contour, lying either in the mid-region of the body (Pl. VII, figs. 7 *d*, 7 *e*) or nearer the anterior end (Figs. 7 *c*, 7 *f*). It measures 30μ in cross-section by 75μ in length. At this stage in the development of the worm the rhabdocoel gut is still undeveloped although the protrusible proboscis is differentiated early in its growth (Pl. VII, figs. 7 *c*–7 *f*). No evidence of the excretory system has been found in studying the larva.

The anlage of the genital system first appears when the gasterostome larva is about half grown (Pl. VII, fig. 7 *d*). In the next stage (Fig. 7 *e*) it becomes differentiated into the cirrus organ (*cs*) and the germ glands (*ga*). In the most mature stage which the larva assumes in the lamellibranch host (Fig. 7 *f*) the germ gland material becomes differentiated into male genital anlage (t_1t_2), ovarian anlage (*ov*) and vitelline anlage (*vit*).

In designating this South African gasterostome as a new species, an attempt has been made to look into the extensive but scattered references to the group. Ssinitzin's species *Cercaria hydriformis* (1911: Pl. III, fig. 49) is a closely related form, but is readily distinguished by the much longer caudal appendages and the less extensive development of the genital anlage. Nicoll's division of the subfamily BUCEPHALINAE into three known genera:

Bucephalus, Bucephalopsis, and Rhipidocotyle (1914: 491) is recognised by the writer as being valid, according to which classification the species under consideration falls into the genus *Bucephalopsis*. The host and the habitat, as well as minor structural differences, all indicate that this species is unlike *B. gracilescens* (Rud.) or other described species of the genus.

The parthenita of *Bucephalopsis modiolae*, like that of other members of the BUCEPHALINAE, is a branched sporocyst.

As for the host of the mature worm, it seems altogether probable that it will be found in the fishes of the Umgeni River where the molluscan host was collected.

7. **Cercaria isidorae** nov. spec. (Pl. VII, fig. 8).

HOST: *Isidora forskali*.

HABITAT: Durban, Natal.

This echinostome cercaria, for which the name *Cercaria isidorae* is proposed, was found once by Dr Cawston in the vicinity of Durban. It is a rather large larva, usually pyriform in shape but at times capable of considerable extension. The body measures about 0·188 mm. in length by 0·09 mm. in breadth, while the tail is nearly twice as long as the body and possesses lateral flutings. Both body and tail are covered with extremely minute spines.

The oral sucker is rounded and measures 30μ in cross-section. The ventral sucker which lies just posterior to the middle of the body is approximately of the same size. The anterior part of the body is set off from the main portion by lateral constrictions, just in front of which are the collar spines. The number of spines on the dorsum has not been counted with certainty, although a total count of dorsal and ventral spines, amounting to about thirty-eight spines, has been made. These spines are acicular and are uninterrupted on the dorsal side of the worm.

C. isidorae has a short prepharynx, although this is seen only in extended specimens. The pharynx (Pl. VII, fig. 8, *p*) is an oval muscular organ 16μ in cross-section. The esophagus is short and frequently telescoped dorsally behind the pharynx. The caeca extend in a broad curve to the subdistal end of the body. There are masses of cephalic secretory glands filling the mesenchymatous spaces both anterior and posterior to the plane of the acetabulum. The main excretory tubules and bladder present a Y-shaped pattern. The cornua just anterior to the acetabulum are packed with excretory granules as far forward as the pharynx, while the granules are commonly present in the bladder proper. The capillaries and flame-cells have not been seen. The collecting tubule in the tail remains unbranched for about three-fourths the distance distad, at which point the tubule divaricates, the lateral branches opening at the margin of the caudal organ. The genital anlage (*ga*) present in the cercaria consists of a clump of cells just in front of the acetabulum, from which a cord of cells extends anteriad to the pharyngeal plane. In

addition, the vitelline elements (*vit*) have become differentiated, with transverse cords and with anterior and posterior branches.

The subintegumentary layer of the cercaria is packed with cells containing needle-shaped cystogenous bodies. While cysts have not been found, the presence of these cystogenous granules in large numbers indicates that this process is the usual method of transfer to the next host.

The parthenita is a redia possessing pharynx, rhabdocoel gut, neck constriction, birth pore, and two conspicuous "feet."

8. **Cercaria mosaica** nov. spec. (Pl. VII, fig. 9).

Hosts and Habitat: *Isidora forskali*, Toll Gate, Durban, and *I. schackoi*, Amatikulu, Zululand.

This larva, for which the name *Cercaria mosaica* is proposed, has certain resemblances to a monostome cercaria, but is without doubt an amphistome because of the well-developed posterior acetabulum (Pl. VII, fig. 9, *vs*). The body of the worm is obovate, and measures 0·4 mm. in length by 0·168 mm. in greatest breadth. The tail measures about one and one-half times the body length. Both body and tail are aspinose. The oral sucker is oval in shape and measures 70μ in cross-section. The posterior acetabulum (*vs*) is much longer than broad, measuring about 120 by 70μ. The dorsal surface of the anterior portion of the larva is characterised by a pigmentation having a bisymmetrical mosaic pattern, which has suggested the name for the cercaria.

The cercaria possesses a small powerful muscular sac within the orifice of which are the extensive tubules of the digestive system (*c*) reaching to the plane of the acetabulum. No details of the excretory system have been observed. The genital anlage (*ga*) consists of a mass of cells (probably the ovary) just in front of the acetabulum, two small masses (the anlage of the testes) laterally disposed in a plane slightly behind the ovary, each connected with the latter organ by a cord of cells, and a fourth cell mass (possibly the male secondary sexual apparatus), situated some distance behind the fork of the digestive tract, and connected with the central genital anlage by a cord of cells. Such a picture is extremely suggestive of the topographic relations of the genital organs of members of the genus Gastrothylax, which is known to occur in ruminants in South Africa.

No cephalic secretory glands have been observed. The subintegumentary tissues of the body are packed with cystogenous cells containing rhabditiform granules. While cysts have not been observed, this type of amphistome together with its encystment apparatus favours the view that this organism is transferred passively to its final host in an encysted condition.

Cercaria mosaica develops in a redia, the rhabdocoele gut of which almost fills its body cavity, leaving room for only a few cercariae to develop at one time.

9. Cercaria of **Gastrodiscus aegyptiacus** (?) (Pl. VII, figs. 10 *a*–10 *b*).

HOST: *Planorbis* sp.

HABITAT: Umgeni River, Durban, Natal.

This species corresponds in all respects which the writer has been able to observe with the cercarial stage of *Gastrodiscus aegyptiacus* as described by Looss (1896: 177–185, figs. 136–139). Even though Looss (*l.c.*) found different species of snails (*i.e.*, *Cleopatra bulimoides* and *C. cyclostomoides*) to serve as molluscan hosts of his material, the two forms of cercariae are so closely akin that they either represent the same species or closely related ones. In view of the very close if not identical relationship of the Egyptian and the Natal material it seems wise to refer the South African cercaria to this species until further investigation is made.

10. **Cercaria biflagellata** nov. spec. (Pl. VII, fig. 11).

HOST: *Isidora tropica*.

HABITAT: Ficksburg, Orange Free State.

This interesting cystophorous cercaria, for which the name *Cercaria biflagellata* is proposed, was found once in *Isidora tropica*, collected by Dr Cawston at Ficksburg. As in most other members of this larval group, the body of the fluke is extremely inconspicuous and immature, while the cyst-like caudal organ and its appendages are both conspicuous and unique.

The body (*b*) is that of a simple distome measuring 0·32 mm. long by 0·08 mm. in breadth with a muscular oral sucker at the anterior end and a somewhat smaller ventral sucker slightly in front of the middle of the body. Within the oral sucker is a small muscular pharynx, behind which is a short oesophagus leading into two caeca which extend to the posterior part of the body. No further internal differentiation has been observed.

The caudal appendage or cyst (*cy*) is considerably larger than the body. It is somewhat flask-shaped, although irregularly so. Coiled up within it is a tube, the proximal three-fifths of which consist of non-muscular elements. Behind this region is a coiled spring or trigger hair (*tr*), the function of which is problematical. The last fifth of the caudal cyst encloses a simple hollow tubule which forks just outside the cyst to form a pair of hollow tubules or flagella (fl_1, fl_2), whose length is from six to eight times that of the cyst. The condition of the caudal organ as described here obtains only in the mature larva. In immature forms the entire flagellar organ is coiled inside the cyst. There is no evidence that the body of the larva can be introverted into the cyst. The function of the caudal appendage appears to be that of locomotion, although it is possible that it also serves as a means of entanglement for the larva.

Cercaria biflagellata develops in large numbers in a redia with a large muscular pharynx, and with a rhabdocoele gut which occupies a considerable

part of the body cavity of the redia. In this respect it is similar to the usual form of cystophorous cercaria.

This species differs from all types of described cystophorous cercariae in the possession of the bifurcated hollow tubular flagellar process. *Cercaria californiensis* (Cort and Nichols, 1920) has two transparent ribbon-like appendages attached to this distal extremity of the cyst and also a bulbus. *C. californiensis*, like *C. macrura* (Faust, 1921, figs. 9–13) and *C. invaginata* (Faust, 1924, fig. 16), possesses an excretory tubule (*lr*), which is present in the mature larva. While the rudiments of this lateral appendage can be found in very young specimens of *C. biflagellata*, the organ degenerates very early. The extraordinary appendages described for *C. sagittarius* and *C. laqueator* (Ssinitzin, 1911) have no counterpart in *C. biflagellata*.

C. biflagellata is the second cystophorous cercaria to be described from South Africa and possibly from Africa. The form described by Sonsino (1892) and Looss (1896) as *Cercaria capsularia* develops in a sporocyst rather than a redia and probably does not belong to this group.

Dr Maurice C. Hall has informed the writer that the name *C. macrura* Faust, 1921, used to designate the cystophorous larva obtained from *Planorbis pfeifferi* at Merebank and Mayville (Durban) is preoccupied by a cercaria referred to briefly by Janicki (1920). The writer has not been able to consult the source reference involved but in order to avoid confusion in the matter proposes that the South African cystophorous species first designated as *C. macrura* be renamed *Cercaria macrocercoides* nov. nom. pro *C. macrura* preocc.

11. **Cercaria paracephaladena** nov. spec. (Pl. VII, fig. 12).

HOST: *Isidora tropica*.

HABITAT: Ficksburg, Orange Free State.

This cercaria, for which the name *Cercaria paracephaladena* is proposed, was found once by Dr Cawston in *Isidora tropica* at Ficksburg. In some respects it bears a resemblance to *C. cephaladena* (Faust, 1921, fig. 6), but is certainly not the same species. It is a xiphidiocercaria with an elongate oval body and a heavy muscular tail. The body measures 0·16 mm. in length by 0·066 mm. in breadth. The tail has a length about one and one-half that of the body. Both body and tail are covered with an integumentary armature of minute spines.

The oral sucker is round and measures 30μ in diameter. The ventral sucker is situated in the mid-plane of the body and measures 24μ in diameter. There is a very short prepharynx, a conspicuous pharyngeal sphincter, and an oesophagus and caeca which are diagrammatically characteristic of this group. The excretory bladder consists of a small spherical chamber, separated from the enlarged cornua (*ex*) by a simple sphincter constriction. No further details of this system have been observed. The genital anlage (*ga*) consists of a coil of cells in the region of the acetabulum.

Inserted into the dorsal wall of the oral sucker is a rather long, narrow, stubby stylet, which would appear to be unable to aid materially in penetrating host tissues. The cephalic secretory glands (*cg*), consisting in this species of about eight pairs of cells with a basophilic reaction, are likewise probably incapable of secreting a sufficient amount of histolytic substance to effect erosion or digestion of such tissue. It is evident, therefore, that this species has had to resort to other means to secure transfer to the next host. The question seems to have been answered in the large amount of material packed into cystogenous cells filling the entire subintegumentary tissues. Cysts have been observed. The cyst possesses a thick capsule.

C. paracephaladena develops in a long sporocyst with thickened walls. The cercariae are proliferated from germinal epithelium localised at one end of the sporocyst.

12. **Cercaria burnupiae** nov. spec. (Pl. VII, fig. 13).

HOST: *Burnupia trapezoidea.*

HABITAT: Botanic Garden, Durban, Natal.

The cercaria for which the name *Cercaria burnupiae* is proposed is a small xiphidiocercaria found in three collections of infected *Burnupia trapezoidea* taken by Dr Cawston from the Botanic Garden, Durban.

The body is regularly oval, measuring 0·28 mm. in length by 0·14 mm. in breadth. The tail is slightly longer than the body. Both body and tail are covered with an integumentary armament of minute spines. The oral sucker is large for the size of the cercaria (80μ in diameter) but the ventral sucker (*vs*), which is situated some little distance behind the mid-plane of the body, is only half that diameter. The stylet which is set into the dorsal wall of the oral sucker has a sharp point and a short shank. Just inside the oral sucker is a short prepharynx, which is provided with a cluster of transversely placed goblet-shaped glands (*ppg*). Behind this region is a small pharyngeal bulb. No further details of the digestive system have been observed.

The cephalic secretory glands consist of four pairs of cells situated just in front of the acetabulum, with fine granular content which is acidophilic in reaction. The ducts to the glands are inconspicuous structures emptying on either side of the stylet. The excretory bladder is a round chamber (*bl*) with elongate sausage-shaped cornua (*c*). Details of the collecting tubules have not been observed. The close resemblance of this species to *Cercaria indica LVII* (Sewell, 1922: 177, figs. 1, 2) makes it seem likely that the flame-cell formula of the South African species is a simple one like that of the Indian form, which is 2 (2 + 2). The genital anlage consists of a central conical mass of cells in the region of the ventral sucker (*ga*), and the vitelline glands (*vit*), which have early become differentiated from the germinal mass and constitute branched fan-shaped masses of granular cells lateral to the ventral sucker.

The parthenita is a long irregular sausage-shaped sporocyst.

No cystogenous glands have been found and cysts have not been observed.

Two species described by Looss (1896), *Cercaria cellulosa* and *C. exigua*, as well as Sewell's *C. indica LVII* (*l.c.*), evidently belong to the same group in which *C. burnupiae* is placed, but all three of these forms differ from the South African species in several particulars, including digestive and excretory systems and secretory glands.

13. **Cercaria microxiphifera** nov. spec. (Pl. VII, fig. 14).

HOST: *Isidora* sp.

HABITAT: Municipal Gardens, Lourenço Marques, P. E. Africa.

This xiphidiocercaria, for which the name *Cercaria microxiphifera* is suggested, is an oval larva with blunt ends, and a long heavy tail, filled with semiglandular cells (*cgd*) along its central core. The body measures 0·24 mm. in length by 0·11 mm. in breadth, while the tail is about twice as long as the body and has a maximum transverse diameter of 40μ. The oral sucker and the ventral sucker are subequal, having a cross-sectional measurement of 68 to 70μ. Both body and tail are aspinose.

The dorsal wall of the oral sucker is beset with a very minute stylet, resembling a miniature rose thorn. The digestive tract consists of a prepharynx, a small pharyngeal bulb, and a capillary oesophagus and bifurcate caeca (*c*). The cephalic secretory glands (*cg*) consist of two grape-like clusters of from 13 to 16 cells, giving an acidophilic reaction, situated anterior to the ventral sucker, with short ducts opening on either side of the stylet. No details of the excretory system have been observed. The genital anlage (*ga*) consists of a coiled mass of cells situated dorsal to the ventral sucker.

The parthenita is an oval elongate sporocyst.

Cysts have not been observed and cystogenous glands have not been found.

14. **Cercaria segmentinae** nov. spec. (Pl. VII, fig. 15).

HOST: *Segmentina planodiscus*.

HABITAT: Durban, Natal.

This xiphidiocercaria, for which the name *Cercaria segmentinae* is proposed, has a small elongate body measuring 0·18 mm. in length by 0·054 mm. in breadth, and a tail 0·14 mm. long. The body has an integumentary covering of minute spines but the tail is aspinose. The oral sucker measures 26μ in cross-section by 38μ in length, and the ventral sucker, which lies just behind the mid-plane of the body, is round, with a diameter of 36μ. A very minute stylet is inserted into the dorsal wall of the oral sucker.

The digestive tract consists of a prepharynx, a small pharynx, and an oesophagus which dilates somewhat at its forks to form the two caeca. The caeca (*c*) extend but partly around the ventral sucker. The cephalic secretory cells are made up of two clusters of small cells of acidophilic reaction, situated laterally to the pharynx, with ducts opening at the sides of the stylet. The excretory bladder (*bl*) is rounded in outline, with two rounded

cornua. The bladder pore lies posteriorly. The genital anlage (*ga*) consists of a U-shaped coil of cells surrounding one side of the ventral sucker.

Cercaria segmentinae develops in a sporocyst. Encystment usually takes place before the cercaria has emerged from the sporocyst, since the cysts are found in the unruptured sporocysts.

C. segmentinae resembles *C. humilis* Faust, 1921, secured from *Lymnaea natalensis* and *Physopsis africana* in the vicinity of Durban. The general proportions of body and tail, type of digestive tract, excretory bladder and genital anlage, all suggest close relationship, but the cephalic secretory cells are specifically different. It is probable that these two cercariae belong to the same subfamily and possibly to the same genus.

15. **Cercaria paucadena** nov. spec. (Pl. VII, fig. 16).

HOSTS AND HABITATS: *Lymnaea natalensis* from Durban and Schuttes Draai, Basutoland; *Isidora tropica*, from Durban.

This cercaria for which the name *Cercaria paucadena* is proposed is a xiphidiocercaria with an oval elongate body, measuring 0·2 mm. long by 0·076 mm. broad, and possesses a narrow caudal appendage 0·16 mm. long. The body is covered with minute integumentary spines, but the tail is aspinose. The rounded oral sucker measures 36μ in cross-section and the ventral sucker which lies just behind the mid-plane of the body has a diameter of 28μ. A small sharp stylet is inserted into the dorsal wall of the oral sucker.

The digestive tract consists of a short prepharynx, a small, inconspicuous pharynx, an enlarged oesophagus and dilated caeca (*c*) which extend but partly around the ventral sucker. The excretory system is provided with a cylindrical bladder (*bl*) with posterior pore, and slightly inflated cornua. Other details have not been observed. The genital anlage (*ga*) consists of three masses of cells in the region of the ventral sucker.

There are two pairs of cephalic secretory glands (*cg*) with granular acidophilic contents. These cells lie just in front of the digestive caeca. Their ducts open at either side of the stylet.

The parthenita is an elongate oval sporocyst.

Cysts have not been observed and cystogenous granules have not been found. The relationship of the cercaria is not known.

IV. GENERAL CONSIDERATIONS.

Since 1915 when Dr Cawston began the study and collection of larval trematodes from Natal and adjacent areas the knowledge of digenetic trematodes has materially increased, but no phase of the subject has received such attention as that of the cercarial stage in the life-cycle, the stage commonly found in molluscs. With the exception of Sewell's study on Indian cercariae (1922) no single collection of larval flukes has resulted in the discovery of so large a group of new species. This has been due in part, no doubt, to the

fact that the region from which the collection was made had been previously unexplored for trematode parasites of molluscs. But credit must also be given to Dr Cawston for the persistence with which he has collected material

Table II. *Species of Larval Trematodes described from Cawston's Collections.*

TREMATODA.

Subclass I. **Gasterostomata.**

1. *Bucephalopsis modiolae* nov. spec.

Subclass II. **Prosostomata.**

Suborder I. ASPIDOCOTYLEA—not represented.

Suborder II. MONOSTOMATA.

2. *Cercaria sewelli* nov. spec.
3. *Cercaria fulvoculata* Cawston, 1919.

Suborder III. HOLOSTOMATA—not represented.

Suborder IV. AMPHISTOMATA.

4. *Cercaria frondosa* Cawston, 1918.
5. *Cercaria mosaica* nov. spec.
6. *Cercaria* of *Gastrodiscus aegyptiacus* (?).

Suborder V. DISTOMATA.

FASCIOLIDAE.

7. *Cercaria pigmentosa* Cawston, 1919 (= *Fasciola gigantica* Cobbold).

ECHINOSTOMIDAE.

8. *Cercaria catenata* Cawston, 1917.
9. *Cercaria arcuata* Cawston, 1918.
10. *Cercaria constricta* Faust, 1919.
11. *Cercaria* 30-*acanthostoma* Faust, 1920.
12. *Cercaria isidorae* nov. spec.
13. *Cercaria caudadena* Faust, 1921.
14. *Cercaria cucumeriformis* Faust, 1921.

HETEROPHYIDAE (?).

15. *Cercaria oblonga* Faust, 1921.

CYSTOPHOROUS CERCARIAE.

16. *Cercaria macrocercoides* n. n. pro *C. macrura* Faust, 1921 preocc.
17. *Cercaria biflagellata* nov. spec.

XIPHIDIOCERCARIAE.

18. *Cercaria cawstoni* Faust, 1919.
19. *Cercaria puerilis* Faust, 1921.
20. *Cercaria ingracilis* Faust, 1921.
21. *Cercaria cephaladena* Faust, 1921.
22. *Cercaria humilis* Faust, 1921.
23. *Cercaria paracephaladena* nov. spec.
24. *Cercaria burnupiae* nov. spec.
25. *Cercaria microxiphifera* nov. spec.
26. *Cercaria segmentinae* nov. spec.
27. *Cercaria paucadena* nov. spec.

SCHISTOSOMATIDAE.

28. *Cercaria* of *Schistosoma haematobium.*
29. *Cercaria* of *S. mansoni.*
30. *Cercaria octadena* Faust, 1921.
31. *Cercaria milleri* nov. spec.
32. *Cercaria syncytadena* nov. spec.
33. *Cercaria parvoculata* Cawston, 1919.
34. *Cercaria oculata* Cawston, 1917.
35. *Cercaria secobii* Cawston, 1915.
36. *Cercaria gigantosoma* nov. spec.
37. *Cercaria gladii* Cawston, 1918.

SEDES INCERTA.

38. *Cercaria vertebraeformis* Faust, 1921.

Table III. *Host Distribution of South African Cercariae (Cawston Collection).*

Group	*Isidora* spp.	*Lymnaea* spp.	*Planorbis* spp.	*Segmentina*	*Burnupia*	*Melanoides*	*Modiola*
Gasterostomtaa	—	—	—	—	—	—	*Bucephalopsis modiolae*
Prosostomata	—	—	—	—	—	—	—
Aspidocotylea	—	—	—	—	—	—	—
Monostomata	—	*C. fulvoculata*	—	—	*C. sewelli*	—	—
Holostomata	—	—	—	—	—	—	—
Amphistomata	*C. frondosa* (=*C.* of *Paramphistomum caticophorum*)	—	*C.* of *Gastrodiscus aegyptiacus* (?)	—	—	—	—
	C. mosaica	—	—	—	—	—	—
Distomata	—	—	—	—	—	—	—
Fasciolidae	—	*C. pigmentosa*	—	—	—	—	—
Echinostomidae	*C. catenata*	*C. catenata*	*C. catenata*	—	—	—	—
	C. arcuata	*C. arcuata*	*C. caudadena*	—	—	—	—
	*C. constricta**	—	—	—	—	—	—
	*C. 30-acanthostoma**	—	—	—	—	—	—
	C. isidorae	—	—	—	—	—	—
	C. cucumeriformis	*C. cucumeriformis*	—	—	—	—	—
Heterophyidae (?)	—	—	—	—	—	*C. oblonga*	—
Cystophorous Cercariae	*C. biflagellata*	—	*C. macrocercoides*	—	—	—	—
Xiphidiocercariae	*C. cawstoni**	*C. cawstoni*	*C. cawstoni*	*C. segmentinae*	*C. burnupiae*	*C. puerilis*	—
	C. ingracilis	—	—	—	—	—	—
	C. cephaladena	—	—	—	—	—	—
	*C. humilis**	*C. humilis*	—	—	—	—	—
	C. paracephaladena	—	—	—	—	—	—
	C. microxiphifera	—	—	—	—	—	—
	C. paucadena	*C. paucadena*	—	—	—	—	—
Schistosomatidae	*C.* of *S. haematobium**	*C. milleri*	—	*C. milleri*	—	—	—
	C. of *S. mansoni*	—	—	*C. syncytadena*	—	—	—
	*C. octadena**	—	—	—	—	—	—
	*C. parvoculata**	—	—	—	—	—	—
	*C. oculata**	—	—	—	—	—	—
	*C. secobii**	—	—	—	—	—	—
	C. gigantosoma	—	—	—	—	—	—
	C. gladii	—	—	—	—	—	—
Sedes Incerta	*C. vertebraeformis**	—	—	—	—	—	—

* From *Isidora* (*Physopsis*) *africana*.

and for his intense interest in the problem. It is the writer's conviction that the Cawston collections have not only added no little part to the present knowledge of larval trematodes and through them to information on the molluscan host distribution, but also to the inter-relationship and life-cycles of members of the group.

Altogether, resulting from this collection, thirty-eight distinct species of larval trematodes have been found, of which all but four are new to science. Inspection of Table II, which shows the systematic position of all these species, indicates a wide range in distribution of the group, although the preponderating subgroups are those of the fork-tailed distomate blood flukes and of the xiphidiocercariae. These same groups, however, are the ones which are large in any larval fluke survey (*vide* Faust, 1919, 1924, Sewell, 1922, Kobayashi, 1922, McCormick, 1923). Table III shows the host distribution of the group under consideration. It can be seen at a glance that the most heavily infected genus is *Isidora* (including *Physopsis*). This is not surprising, since it is represented by five species, of which *Isidora* (*Physopsis*) *africana* is most usually and most heavily infected. A total of twenty-five species of cercariae are harboured by members of this genus. Of these, nine species were found in *Isidora africana* alone. Six of the same species of parasites found in Isidorae have also been found in *Lymnaea natalensis*, showing an alternative in molluscan hosts which these forms may utilise.

V. SUMMARY AND CONCLUSIONS.

1. Fourteen species of larval trematodes are described from South African material, of which thirteen are new to science.

2. These forms are described and their relationship to previously described cercariae and to adult flukes is discussed.

3. The cercariae of the human blood flukes of South Africa are brought up for detailed consideration. A restudy of the material in the writer's possession, including the original experimental material of *Schistosoma mansoni* from Venezuela, is presented.

4. The writer restates his original thesis:

The essential differentiating features of the apharyngeal fork-tailed cercariae consist in the number and microchemical reactions of the secretory cells. These structures can be studied and differentiated from well-preserved material as well as from fresh material.

5. *Isidora* (*Physopsis*) *africana* from Natal is known to harbour three species of mammalian schistosome larvae, of which (*a*) one, originally diagnosed by the writer as the "Cercaria of *Schistosoma haematobium*," is found on re-examination to correspond to the larva which Blacklock and Thompson have found experimentally to be this species; (*b*) a second species corresponds exactly with that known experimentally to be the cercaria of *Schistosoma mansoni* in Venezuela; while (*c*) a third (*C. octadena*) is probably that of *Schistosoma bovis*, which is known to be present in Natal.

6. A table is presented which embodies the important diagnostic features of the three human blood-fluke cercariae.

7. The systematic position of the thirty-eight species of larval trematodes described from Cawston's collections and their host relationships are summarised.

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EXPLANATION OF PLATES VI AND VII.

PLATE VI.

Figs. 1 *a*–1 *c*. *Cercaria sewelli*. 1 *a*, dorsal view of larva, showing body, tail and outline of tail coiled in a characteristic fashion; 1 *b*, lateral view of body; 1 *c*, sporocyst with one maturing cercaria and three developing germ-balls.

Figs. 2 *a*–2 *c*. *Cercaria milleri*. 2 *a*, lateral view of body, showing structural details; 2 *b*, outline sketch of entire larva; 2 *c*, distal portion of caudal furcus.

Figs. 3 *a*–3 *c*. *Cercaria syncytadena*. 3 *a*, ventral view of body; 3 *b*, lateral outline sketch of entire larva; 3 *c*, distal portion of caudal furcus.

Figs. 4 *a*–4 *b*. *Cercaria gigantosoma*. 4 *a*, ventral view of entire larva, showing structural details; 4 *b*, distal portion of sporocyst, showing characteristic germinal rachis.

Figs. 5 *a*–5 *c* and 6 *a*–6 *f*. Sagittal and transverse sections through critical areas of the cercaria of *Schistosoma mansoni*, showing cephalic secretory glands and ducts. 5 *a*–5 *c*, three serial sagittal sections; 6 *a*–6 *f*, six serial transverse sections. In 5 *a*–5 *c*, acidophilic gland ducts occur in sections lateral to 5 *a* and 5 *c* and consequently do not appear in the series.

NOTE. Red designates basophilic gland cells; other gland cells shown in black. All drawings on this plate were made with the aid of a camera lucida.

PLATE VII.

Figs. 7 *a*–7 *f*. *Bucephalopsis modiolae*. Successive stages in the development of the fluke. 7 *f*, mature larva, body only, showing detail of genital anlage; anterior and ventral sucker greatly contracted.

Fig. 8. *Cercaria isidorae*. Ventral view of body, showing structural details of worm.

Fig. 9. *Cercaria mosaica*. Optical view showing detail of structures in body of worm.

Fig. 10. *Cercaria* of *Gastrodiscus aegyptiacus* (?). 10 *a*, sketch showing important details of worm; 10 *b*, redia, with developing cercaria.

Fig. 11. *Cercaria biflagellata*. Sketch of the larva, including body, caudal cyst and flagella.

Fig. 12. *Cercaria paracephaladena*. Ventral view of body, showing structural details.

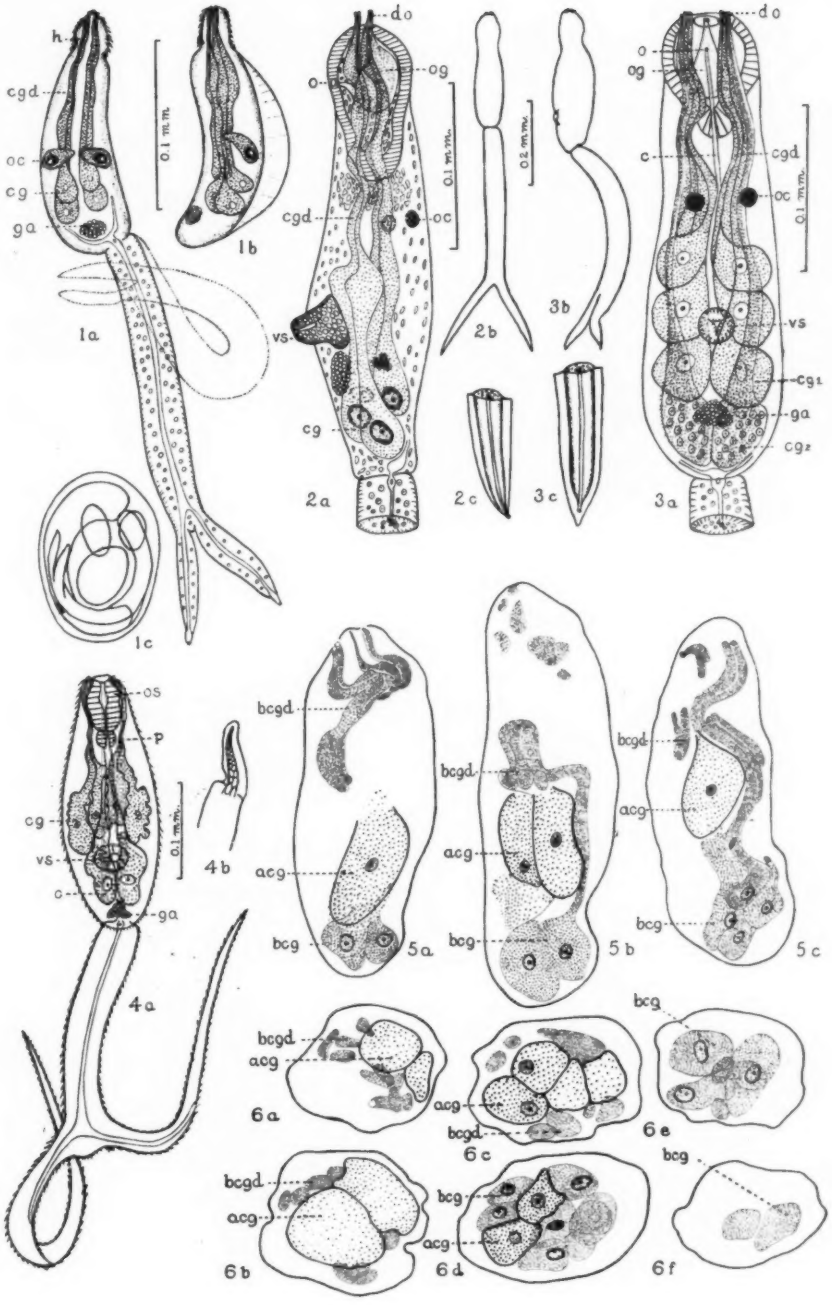
Fig. 13. *Cercaria burnupiae*. Ventral view of body, showing structural details.

Fig. 14. *Cercaria microxiphifera*. Ventral view of body and tail, showing structural details.

Fig. 15. *Cercaria segmentinae*. Ventral view, showing structural details.

Fig. 16. *Cercaria paucadena*. Ventral view, showing structural details.

NOTE. All drawings on this plate were made with the aid of a camera lucida.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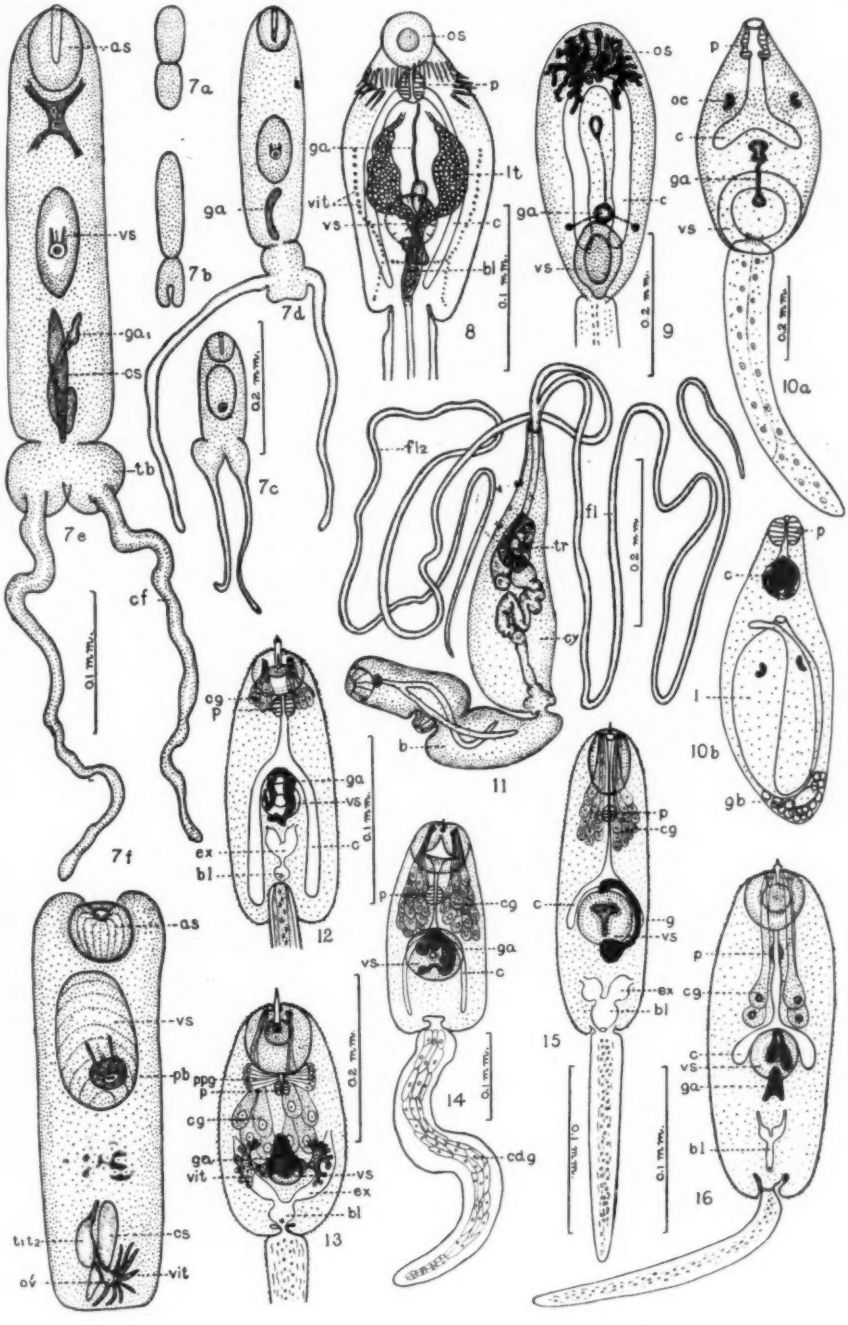
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0.2 m.m.
9
10a
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b
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0.1 m.m.
12
p
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14
cdg
p
cg
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vs
ex
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15
0.1 m.m.
p
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c
vs
ga
bl
0.1 m.m.
16
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13
t1 t2
cs
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vit

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EXPLANATION OF LETTERING.

acg, acidophilic cephalic gland.
acgd, acidophilic cephalic gland duct.
as, anterior sucker.
bcg, basophilic cephalic gland.
bcgd, basophilic cephalic gland duct.
bl, bladder.
c, caecum.
cdg, caudal gland cells.
cf, caudal flagellum.
cg, cg_1, cg_2, cephalic glands.
cgd, cephalic gland duct.
cs, cirrus sac.
cy, caudal cyst.
do, cephalic gland duct opening.
ex, excretory collecting tubule.
fl_1, fl_2, flagellar processes.
ga, ga_1, genital anlagen.
gb, germ-balls.
h, head.
l, larva (cercaria).
o, opening of digestive tube.
oc, eye-spot.
og, oral gland (head gland of Cort).
os, oral sucker.
ov, ovary.
p, pharynx.
pb, proboscis.
ppg, prepharyngeal glands.
t_1, t_2, testes.
tb, tail bulbus.
tr, trigger hair.
vit, vitelline glands.
vs, ventral sucker (acetabulum).

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ON SOME FILARIAE PARASITIC IN SURINAM MAMMALS, WITH THE DESCRIPTION OF *FILARIOPSIS ASPER* N.G., N.SP.

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(With 17 Text-figures.)

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Introduction.

Although our knowledge of Filariae parasitic in animals is continually increasing, the main source of information concerning this group remains still confined to the important monographs by Molin (1858) and Stossich (1898). Molin's descriptions of worms are, however, often so incomplete that in using them as a basis of classification Diesing failed in his attempt to subdivide the genus *Filaria*, whilst Stossich's descriptions are scarcely better than those of Molin. Stiles has already pointed out the absence of clear and definite characters for the subgenus *Filaria* of which *Filaria martis* Gmelin is the type-species. Before any new division of the genus *Filaria* is proposed the writer thinks it is advisable to re-investigate the already known species and to re-describe them more carefully, laying special stress on such characters as the structure of the female genital organs and the structure of the microfilariae. The knowledge of Filariae parasitic in animals will be of great help in identification of worms parasitic in man.

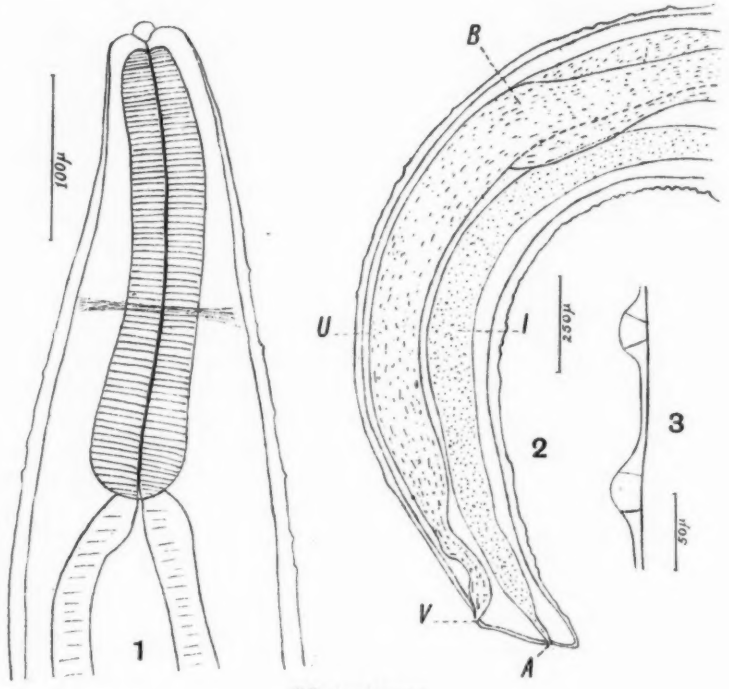
In the present paper the term *Filaria* will be used in its widest sense and the description will be given of forms parasitic in monkeys, tiger and "pakira" collected by Dr C. Bonne in Surinam. The worms were examined in Amann's lactophenol[1], and, when a portion of a female could be sacrificed, its uterus was removed close to the vulva and stained with haematoxylin.

[1] See Langeron (1921), *Précis de Microscopie*, p. 493.

FILARIOPSIS ASPER n.g., n.sp.

(Figs. 1, 2, 3, 4 and 5.)

Some well preserved females and males were collected from the lungs of a "roaring-monkey" (*Alouata* = *Mycetes seniculus* L.). The females are from 17·5 to 21 cm. long with a maximum thickness in the middle of the body of 0·52 mm.; the posterior end of the body is slightly broader (0·56 mm.).



Filariopsis asper.

Fig. 1. Anterior end.
Fig. 2. Tail of female; *B*, bifurcation of uterus; *U*, uterus; *I*, intestine; *V*, vulva; *A*, anus.
Fig. 3. Conical protuberances of the cuticle.

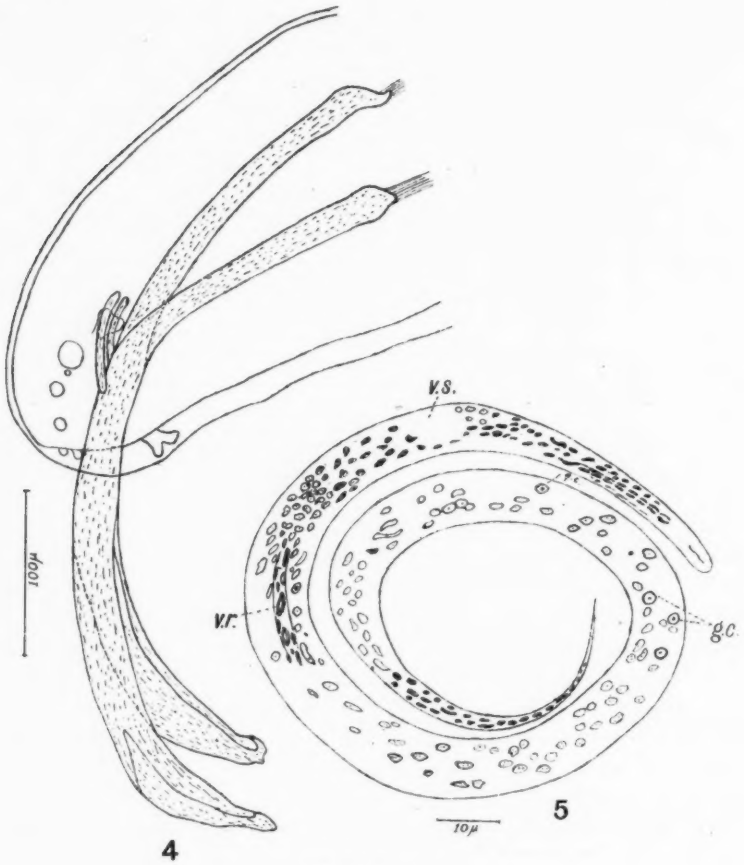
The males, which are less attenuated, are some 11 cm. long and have a maximum breadth of 0·45 mm.

The cuticle is covered by irregularly placed conical elevations, which, in the middle of the body measure 22·8 μ × 11·4 μ, but which are absent or very small on the head and tail. Lateral alae and cervical papillae are absent.

The very small buccal cavity is bordered by three conspicuous lips, one of which seems to be pierced by the small duct of a gland[1]. The oesophagus

[1] This structure is omitted in Fig. 1 as it is doubtful.

is 0·25–0·28 mm. long, very muscular; its diameter anteriorly is 0·44 mm., in the middle 0·53 and posteriorly, where it forms a bulb, 0·53 mm. Intestine about half as wide as the body. Nerve ring near the posterior part of the oesophagus.



Filariopsis asper.

Fig. 4. Tail of male, lateral view.
Fig. 5. Microfilaria; *v.s.*, anterior "V-spot"; *v.r.*, viscus rudiment; *g.c.*, genital cells (?).

Female. Body stout, ending with a very short obtuse tail. Anus situate 0·42 mm. from the caudal extremity. The vulva is remarkable in that it is situated only 0·15 mm. in front of the anus. The vagina is 0·2 mm. long; bifurcation of the uterus is situated at 0·5 mm. from the vulva. Two ovaries and two uterine tubes are replete with ova containing embryos in various

stages of development; when extruded into the uterus, the well-formed embryos are enclosed in the membranous egg-shell, which subsequently becomes the sheath of the microfilaria. Near the vagina these sheaths are not visible and it is not known if the microfilaria in the blood of the host are ensheathed.

The microfilaria, shortly before being liberated by the female, is curled up, very large, ca. 300μ long and 10·5μ broad in the middle. The microfilaria, when stained with haematoxylin, shows an extremely delicate spicule (?) anteriorly, followed by an area (45·8μ long) with very dark granules, not yet differentiated young nuclei, the anterior of which are arranged into a column forming an anterior viscus rudiment. Nerve-ring not visible in this area, which is followed by the anterior "V-spot"; behind it are found more developed nuclei, the posterior of which form a sort of viscus. The rest of the interior up to the tail is filled up by an undifferentiated substance containing a few well-developed nuclei, probably four of which represent the four small genital cells. "Tail-spot" not well limited. Tail with embryonic granules.

Male. Body much slenderer than that of female; conical cuticular protuberances not so high. The cuticle at the sides of the tail posteriorly spreads slightly outwards forming two minute caudal alae, which meet terminally, each bearing five papillae, the anterior of which is bilobed. Two slightly curved equal spicules (375μ long and 28·5μ broad, near posterior end) are supported by two gubernacula 79·8μ long. At rest the spicules and gubernacula are inside the body. In one of the specimens (Fig. 4), the spicules are protruded. Vas deferens runs up till 0·34 mm. from the point of the tail. Spermatozoa almost round, 19μ in diameter.

Affinities. This very interesting filaria is characterized by the conical protuberances of the cuticle, the situation of the vulva close to the anus, the very broad curled-up microfilariae and the equality of the two spicules. In the monograph of Stossich, under Nos. 26, 29, 68, 231, 279 and 301, species of *Filaria* and of *Spiroptera* are mentioned, which have a similar situation of the vulva. It is impossible to decide how far these worms are related to the parasite described by me. The above-mentioned characters of the new worm differ, however, so much from those of the subgenus *Filaria*, mentioned by Stiles, that the creation of the new genus *Filariopsis* is amply justified.

FILARIA GRACILIS Rudolphi, 1809.

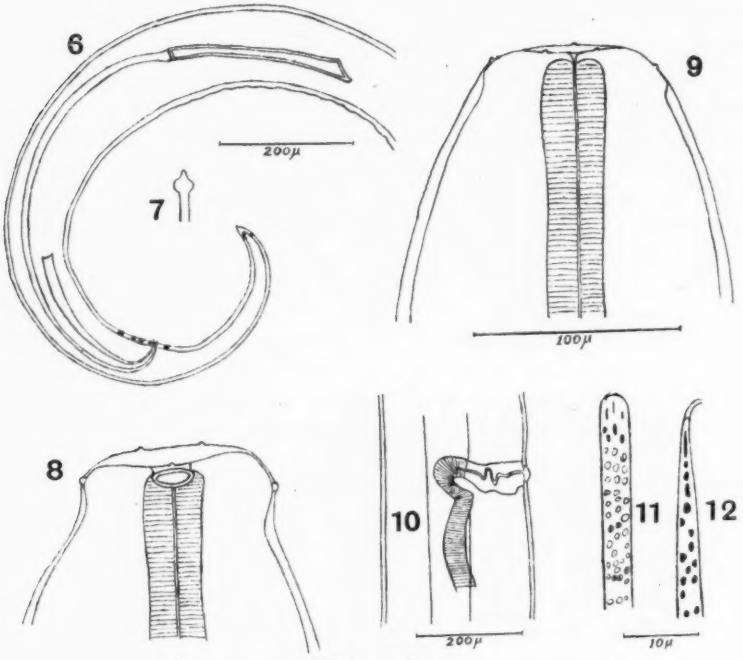
(Figs. 6, 7, 8, 9, 10, 11 and 12.)

Some males and females were collected from the peritoneal cavity of a *Cebus* spec., the common brown monkey. Females measure 16–24 cm., males 7·5–10 cm. in length.

In the main I agree with the recent note of Ortlepp on this worm. Contrary to him, I observed that the left spicule in three males is 0·88 mm. long, as stated by Dujardin and von Linstow. The measurements of the right spicule

agree with that of Dujardin and Ortlepp. A gubernaculum could not be found. Ortlepp is the first to describe the structure of the left spicule adequately.

In a female, 21 cm. long, the vulva is situated 1·4 mm. from the anterior extremity. Vagina membranous, followed by the trunk, which is transversely striated, at least over an area of 10 mm. At 1·5 mm. from the anterior end



Filaria gracilis.

Fig. 6. Tail of male with spicules.
Fig. 7. Tip of the left spicule.
Figs. 8 and 9. (Same scale.) Two types of the anterior end.
Fig. 10. Genital aperture of female.
Fig. 11. Anterior end of microfilaria.
Fig. 12. Tail of microfilaria.

of the body is the bifurcation of the uterus; the two uterine tubes run nearly in a straight line towards the tail, except at their base, where, at 27 mm. from the last uterine-winding, they are closely twisted together with the finer ovary-terminations.

Eggs in the beginning of the uterus measure $22{\cdot}8\mu \times 17{\cdot}1\mu$. Microfilariae near the vagina are ensheathed and very slender ($3{\cdot}5\mu$ in diameter). The "V-spot" is very narrow, 30μ from the anterior end, often invisible; "tail-spot" better developed, $22{\cdot}5\mu$ from the caudal point. Embryonic

granules differentiated only in the anterior end; an area of 12 μ long in the middle of the body forms a viscus rudiment. Once a single genital cell could be distinguished, but its situation could not be defined.

The anterior end of the body shows five small papillae, not noticed by previous authors (Figs. 8 and 9).

The entrance of the oesophagus in one case was found to be surrounded by a chitinous ring (Fig. 8). The transition of the oesophagus into the intestine is indistinct, it is 0·47 mm. from the anterior end of the body. The oesophagus near the intestine is 45·6 μ broad, the beginning of the intestine being 76 μ in diameter.

Ortlepp, with good reason, regarded *Filaria caudispina* Molin as a synonym of *F. gracilis*. One of the characters not mentioned by Ortlepp, which served Molin for establishing his new species, *caudispina*, is the absence of the lateral incisions in the anterior end of the body. I have found, however, among the examined specimens, worms, more or less completely devoid of this incision, which shows that the species *caudispina* Molin is not justified.

Filaria acutiuscula Molin, 1858.

(Figs. 13 and 14.)

One single female was found under the skin of *Dicotyles torquatus* ("pakira"). The body is 7·7 cm. long with a maximum width of 0·45 mm. on a line with the vulva, whereas the body tapers but slightly toward the ends. The tail is curved.

The vulva is situated at 1·5 mm. from the buccal cavity, which is circular and chitinised. The last part of the uterus is closely coiled (Fig. 13). The two uterine tubes, which originate 12 mm. behind the vulva, have a very thick wall (25 μ), and run almost in a straight line along the axis of the worm towards the tail. The two points, where the uteri join the ovaries, are 2·5 mm. apart, the posterior point situated 0·2 mm. from the anus.

The ovary after making two coils runs together backward with the opposite ovary towards the tail, both ovaries being closely coiled about each other; they terminate at a distance of 48 μ from the anus.

The eggs measure 19–30 μ × 9·5–11·5 μ in the beginning of the uterus. Microfilariae, when in the uterine tubes near the ovijector, appear curled up as in *Filariopsis asper*; they may attain a width of 5·8 μ.

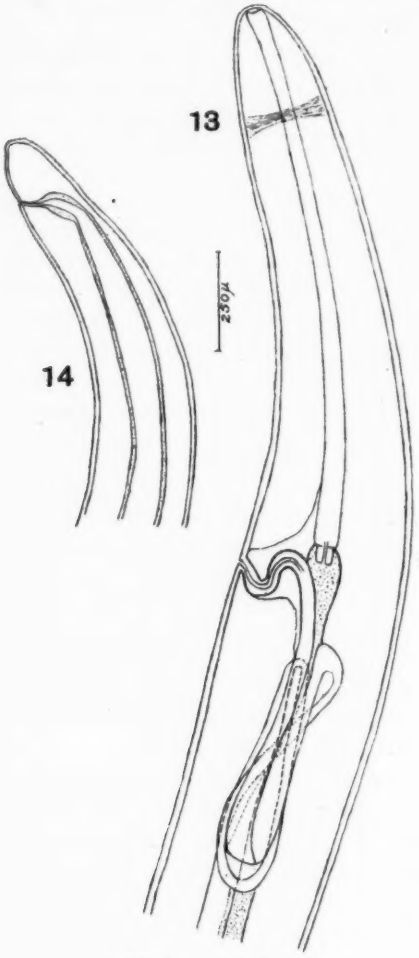
Filaria striata Molin, 1858.

(Figs. 15, 16 and 17.)

Several females were found in the subcutaneous tissue of a tiger-cat, *Felis pardalis* L.

The measurements of a female given by Molin are 13 cm. × 0·3 mm. My measurements are 28·7–33 cms. for the length and 0·5 mm. for the breadth

near the vulva. The anterior extremity shows one small papilla to the left and one to the right of the mouth, and two other small papillae at both sides of the head. Oesophagus 2 mm. long, anteriorly slightly swollen. Anus

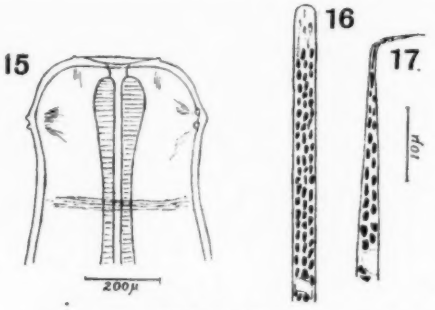


Filaria acutiuscula.
Fig. 13. Anterior end of female.
Fig. 14. Tail of the same female.

situated at the convex side of the curved tail, at the rounded tip of which some females show three papillae measuring 9·5 × 2·9 μ.

Vulva at 1·08–1·84 mm., bifurcation of the uterus at 10 mm. from the head end. The situation and structure of the genital tubes is in the main as given

by Looss for *Loa loa*. Near the vulva the microfilariae are ensheathed and 228–255μ long, the cuticle being finely striated transversely. In a microfilaria 228μ long, the maximum breadth is 3μ at the head end, where a fine "needle" is visible; nerve-ring at 50μ, anterior "V-spot" at 65μ from the anterior end; "tail-spot" at 27μ from the point of the tail, which tapers gradually. Some 60 embryonic granules are situated anteriorly to the nerve-ring, some 24 between that ring and the anterior "V-spot"; more than 200 between "V-spot" and "tail-spot," 22 posteriorly, between the last spot and the point of the tail. Genital cells could not be distinguished. None of the embryonic granules are differentiated into nuclei with nucleoli, this being also



Filaria striata.

Fig. 15. Anterior end of female.
Fig. 16. (Same scale as Fig. 17.) Anterior end of microfilaria.
Fig. 17. Tail of microfilaria.

the case in the well-known *Filaria bancrofti*. In the granular mass between "V-spot" and "tail-spot" the granules in the middle are arranged to form the rudiment of the alimentary canal. The whole of the microfilaria much resembles those of *Filaria bancrofti* and *Loa loa*, and differs markedly from that of *Filariopsis asper*.

Diesing calls the worm *Solenonema striatum*, because in the male the "vagina penis" would be "tubulosa vel subglobulosa." As no males were present in the collection examined by me it has been impossible to verify Diesing's statement. Since Diesing did not sufficiently study the genital apparatus, and other authors have failed to confirm his observations, his genus *Solenonema* must for the present remain doubtful.

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